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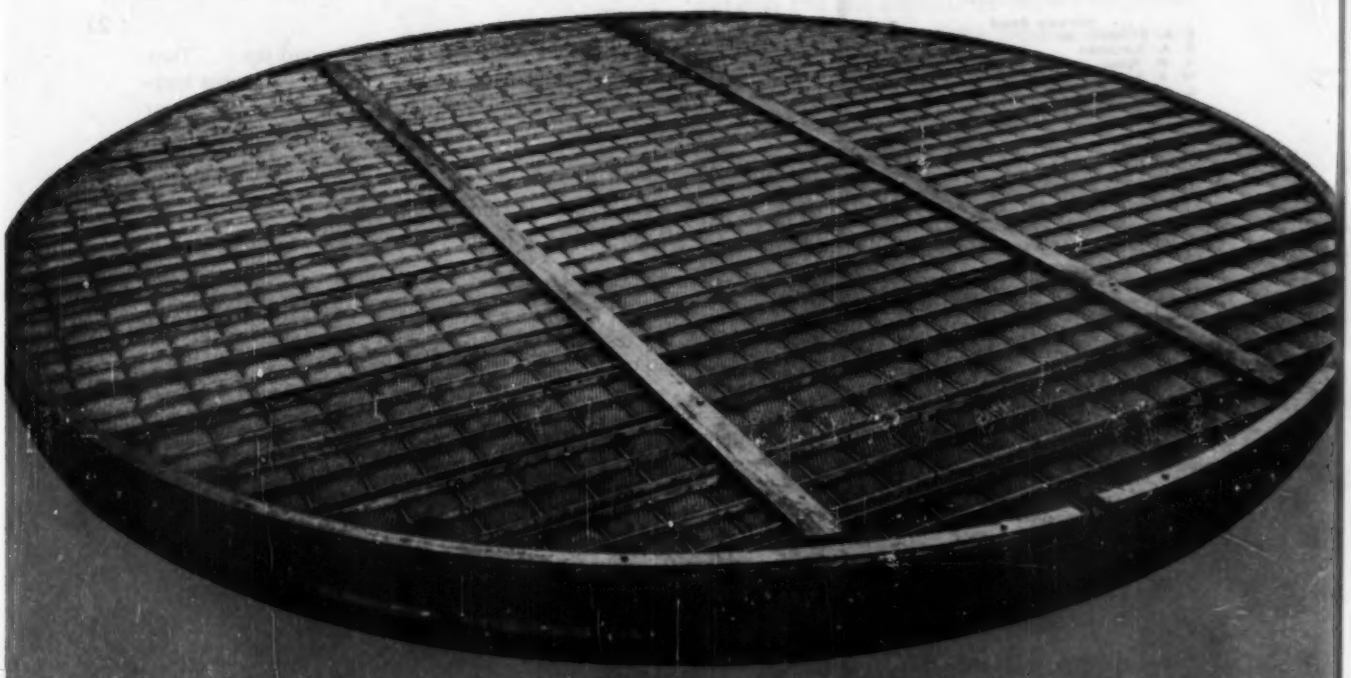

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Students conclave termed success

At the Salt Lake City meeting a two hour panel discussion, "Careers in Chemical Engineering" for students, was held. Panel members were pleased at the good attendance of about fifty students, and the interest the students displayed. At the end of two hours it was evident that the students still had many questions to ask, and, accordingly, the meeting lasted more than three hours rather than the two hours scheduled. Virtually all students stayed the entire time and even after the formal discussion ended groups of students and panel members met in informal groups for further talk.

Students participating were from South Dakota School of Mines and Technology, University of Colorado, Brigham Young University, and the University of Utah. Panel members were R. L. Cummings of Atomic International, who discussed careers in plant operation and production; O. W. Johnson of Dorr-Oliver, whose topic was design and development; E. J. Korchinski of Shell Development, who spoke on graduate study and research; R. J. McGarry of Stone and Webster, who covered sales opportunities. The final speaker was B. T. Mullaney, Manager of Personnel, Crown Zellerbach Corporation, whose talk was on the subject of "Job Yardsticks." Panel moderator was Jess Walton of Oregon State College.

One recurring theme in the questions asked by students was the environment which the young engineer could expect, and what opportunities would exist for the exercise and display of individual merit by a new employee. This theme led to other pertinent questions as to whether an individual in industry would be happier in a large integrated company or in a smaller company. This question was of such interest that all panel members participated in answering it according to their own views. Other questions centered around foreign service, the opportunity or necessity of travel, and the possibilities of interdepartmental transfer in case an employee wished to change the emphasis of his duties.

The unqualified success of this discussion indicates that in a metropolitan area where there are numerous chemical engineering departments, student attendance could well number in the hundreds at such a meeting. Much of the success of the discussion, however, must be given to the individual panel members who were careful not to exceed the time allotted to them, and who must have spent much time and effort in preparing the fine presentation which each contributed.

J. S. WALTON
Oregon State College,
Corvallis, Ore.

What's Your Title?

Symbolism has a good deal more value than most engineers are willing, publicly, to concede. The registered engineers have encouraged, as of symbolic significance, the use of the letters P. E. after their name. I think our technical societies have symbolism of far greater significance than P. E. This view has been confirmed by studies I have made recently of the membership requirements of our technical societies and of the degree of difficulty involved in obtaining state registration in an average state. I think it very fair to conclude that full-grade membership in A.I.Ch.E., for example, has far greater professional significance than accrues from a professional license. I'd like to see the societies prove this by encouraging their members to initiate the practice, as is used in Great Britain and certain other Western European countries, of using the society letters after their name in official correspondence, on desk nameplates, and in a series of other appropriate instances. Membership in our technical societies is not, as you well know, gratuitously conferred. It means something. This is the essence of effective symbolism.

W. T. CAVANAUGH, *Executive Sec'y., Engineering Manpower Commission.*

Columbium-Niobium

In going over the September 1958 issue of *Chemical Engineering Progress,* I was astonished to see, in an engineering magazine published by an American engineering society, an article on the "separation of niobium and tantalum." It has been my impression that the 1951 action of the American Chemical Society of approving the 1949 recommendation of the International Union of Pure and Applied Chemistry (IUPAC) that "niobium" be used instead of "columbium" as the name of element 41 had not been accepted by any professional engineering society nor by any engineer. This non-acceptance is completely logical because: (1) the recommendation violates the long-accepted ethical principal that scientific honors, including the privilege of selecting a name, shall go to the individual or individuals who made the discovery; (2) the amount of columbium used by the chemical industry is infinitesimal compared with the tonnage produced and used by the metallurgical industry, hence it seems important to retain columbium as the name for element 41 as it has been recognized as proper by engineers for half a century; and (3) the action of ACS was inconsistent in that it accepted "niobium" (Nb) instead of "columbium" (Cb) but refused to accept "wolfram" (W) instead of "tungsten" (also W) despite the fact that this change in chemical-element nomenclature was also recommended by IUPAC.

The history of the discovery and naming of columbium by Hatchett in 1801 has been the subject of repeated articles in the technical press and does not need to be summarized again.

The term "columbium" for element 41 was made official by the American Chemical Society in 1910 and remained official until "niobium" was adopted in 1951, apparently with no explanation to ACS members except the statement by E. J. Crane, former chairman of the ACS Committee on Chemical Nomenclature, that ACS went along with IUPAC "in the interest of international unification" (*Chem. Eng. News,* 31, 1953, p. 1577).

On June 16, 1958, the American Institute of Mining, Metallurgical, and Petroleum Engineers, by action of the AIME Board, designated columbium as the official name of element 41 in all AIME publications. Other engineering societies in the United States have, so far as I know, never questioned the propriety of the name columbium for element 41. It seems desirable to me that A.I.Ch.E., as one of the important engineering societies in the United States, should not treat the matter lightly by permitting authors in A.I.Ch.E. publications to use either name but should take the lead in reestablishing the correct name.

FRANK T. SISCO, *Director*
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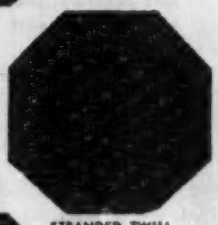
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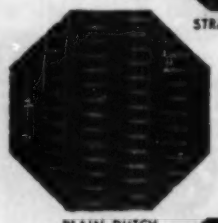
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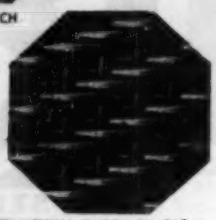
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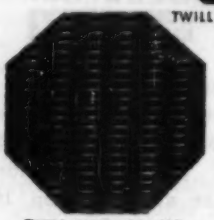
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marginal notes

BUBBLE-TRAY DESIGN MANUAL—*prediction of fractionation efficiency*, Distillation Subcommittee of the A.I.Ch.E. Research Committee, N. Y. (1958) 94 pp. $5.00 to members of A.I.Ch.E., $10.00 to non-members.

The first design manual to be published by the A.I.Ch.E. is the result of a five-year study project by the A.I.Ch.E. Tray Efficiency Research Committee to develop a method of predicting efficiencies for commercial bubble trays used in multicomponent vapor-liquid fractionation. Included in the study were an extensive literature search, a five-year experimental program at several universities, and the evaluation of large amounts of private commercial data made available to the program. From this work a practical method of predicting bubble-tray efficiencies was developed.

The program developed separate correlations for each of four factors (rates of mass transfer in gas and in liquid phases, degree of liquid mixing on the bubble tray, and magnitude of liquid entrainment between trays) in terms of the many variables involved, and verified the reliability of the recommended equations for combining the factors.

W.B.G.

THERMODYNAMICS OF ENGINEERING SCIENCE, S. L. Soo, Prentice-Hall, Inc., Englewood Cliffs, N.J. (1958), xv + 620 p., $9.00.

Reviewed by Kenneth A. Kobe, Department of Chemical Engineering, The University of Texas, Austin, Texas.

An attempt has been made to capitalize on "Engineering Science," but at least, the result is a thermodynamics text which appears better (to a chemical engineer) than most mechanical engineering thermodynamics tests. The author S. L. Soo, assistant professor of mechanical engineering, Princeton Univ., states: "The watchwords of this exposition have been rigor and generality." With some exceptions, these objectives have been achieved.

The first ten chapters cover the fundamentals: introduction, first law, flow systems, second law and reversibility, entropy and the third law, the perfect gas, properties of pure substances, properties of gaseous mixtures, heat transfer, microscopic and mathematical theories of matter. The second group of ten chapters covers applications of the fundamentals: thermodynamics of reactive systems,

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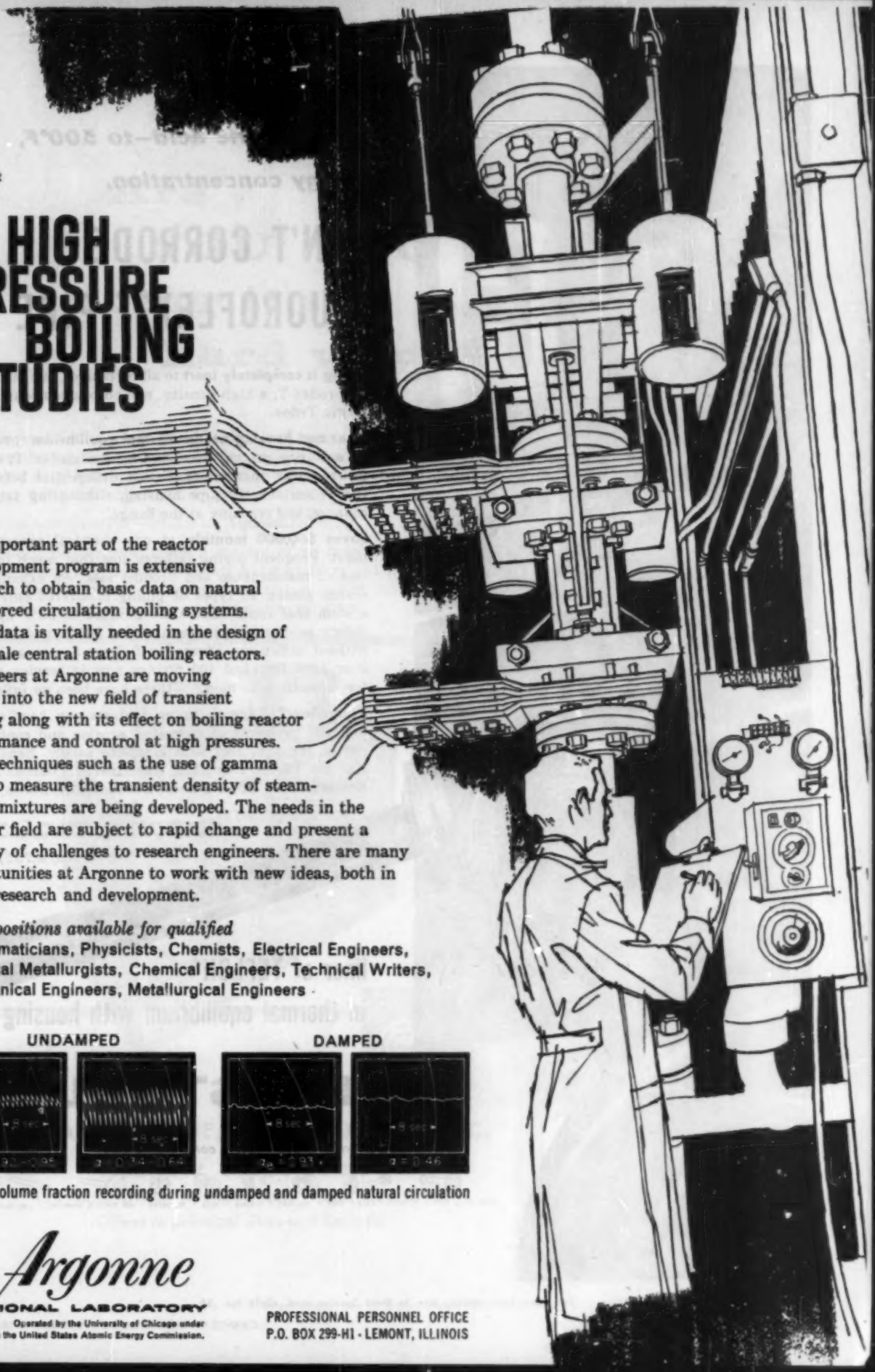

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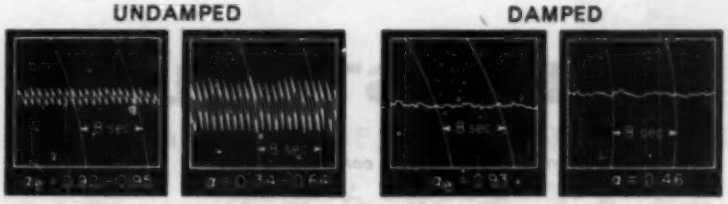

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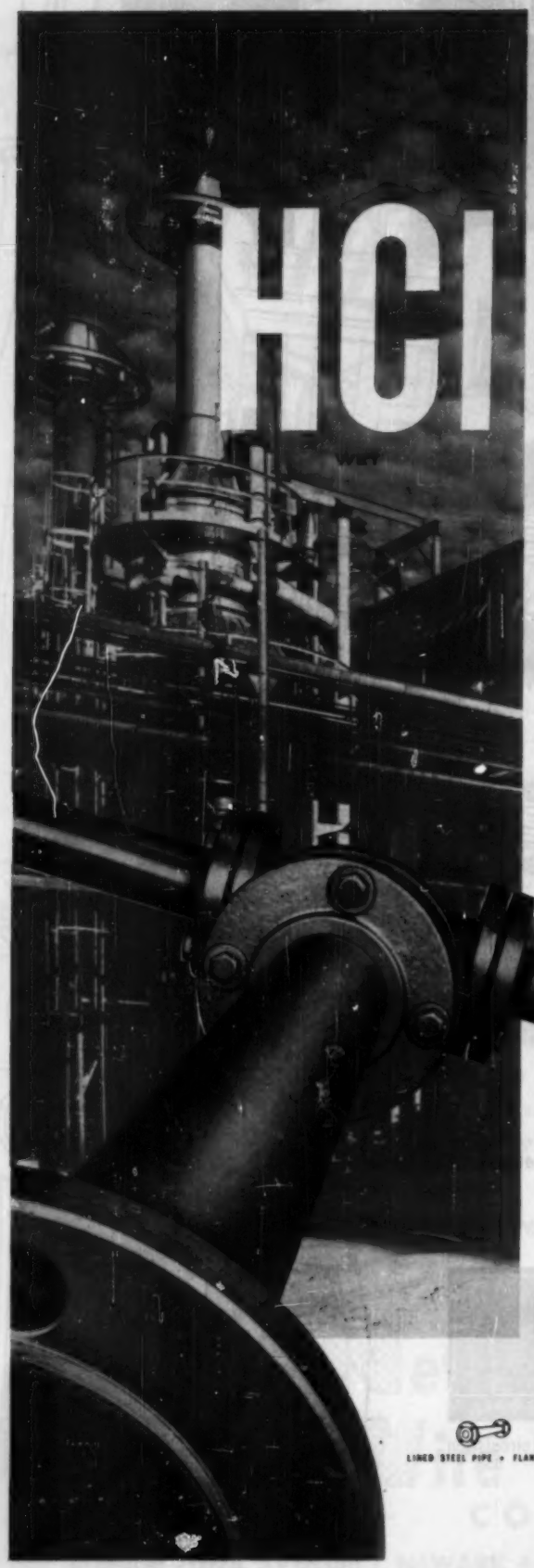

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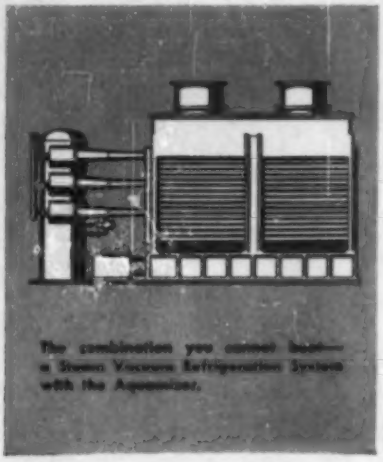

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For more information, turn to Data Service card, circle No. 23

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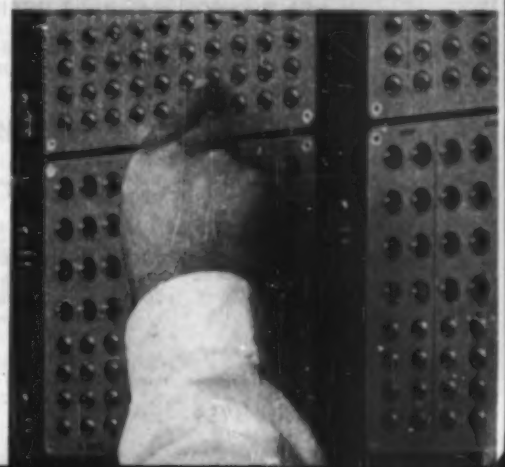
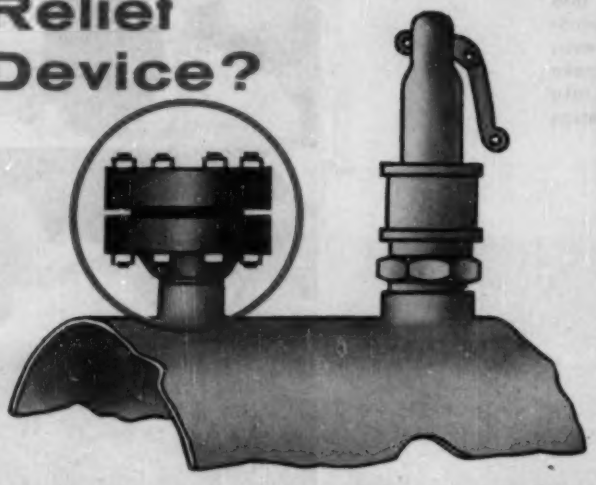


Why The "Standby" Relief Device?



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Your relief valve may need a helping hand.
The double protection provided by this relief valve–BS&B Safety Head combination is ideal when—

- **The nature of the pressurized fluid may cause malfunction of relief valve.**
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When pressure-relief requirement is greater than the discharge capacity of the valve, the BS&B Safety Head provides an instantaneous, unrestricted opening.

Thousands of pressure systems are now protected with the added security of BS&B Safety Heads.

BS&B Engineers will be glad to evaluate your pressure system for application of the correct BS&B Safety Head.

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For more information, turn to Data Service card, circle No. 7

marginal notes

from page 8

compressors and expanders, fluid flow, turbomachinery, ideal gas cycles for the conversion of heat into work, internal combustion engines, gas turbines, vapor cycles and the steam power plant, refrigeration and the heat pump, principles of jet propulsion. An appendix gives many tables of data, Mollier charts, psychometric charts, and the like.

"There ought to be a law" that every teacher of M.E. thermo would take a course in stoichiometry and material balance so they would not make statements like "the product of the molecular weight of a gas in the perfect state and its gas constant is a universal constant." Why can't they learn about the mole unit in freshman chemistry? The compressibility factor for real gases is mentionod briefly, but a formula $Z = 1/(1 - ap)$ infers, that Z is always greater than unity.

Soo follows European practice in defining free energy and free enthalpy. What a shock when the student refers to a chemical thermodynamics or a chemical engineering thermodynamics text!

The treatment of the first law and particularly flow and nonflow systems and their combination is done well. There is no thermochemistry. Ten pages on nuclear reactions is an interesting innovation. The chapter on jet propulsion is stimulating.

This book is a much better than average mechanical engineering thermodynamics text.

This review was written by the late Dr. Kobe just before his recent untimely death—Ed.

CELLULOSICS. Walter D. Paist, Reinhold Publishing Corporation, New York (1958), 270 pp., $5.75.

All those who are working in the plastics and fiber fields should find this summary of the many uses for products formed chemically from cellulose interesting and helpful. The author paints in a background on the production and properties of the cellulosics for the benefit of the reader. Introductory chapters, covering the chemistry, properties, and fabrication methods of the cellulosics precede the many examples of their application. The growth pattern, as shown in one of the accompanying tables, indicates that the major growth immediately ahead will be in cellulosic films (mostly cellophane) and water-soluble derivatives (mostly carboxymethyl cellulose), with some growth in cellulose acetate, and cellulose propionate.

IS FOR ADAPTIONEERING*

(selected from the forthcoming adaptioneering dictionary)

ABRASIVES Grain-resin mixtures present an agglomeration problem. In one S-W installation, 43 Richmond/S-W Gyro-Pedestal Sifters help to maintain the uniform grain size required in the manufacture of resin-bonded abrasive wheels. Other applications include intimate blending of 350-mesh size (flour consistency) ceramic clays and feldspar mixtures.

ACETATE CELLULOSE To reduce acetate cellulose scrap, a large selection of S-W machines may be used. At a typical installation, S-W Rotary Knife Cutters cut waste material into minus 2½" ring size at a rate of 4,000 pounds per hour.

AIRO-FLOW This is the S-W designation for complete pneumatic systems. Positive pressure is usually preferred when conveying from one point to many different points, whereas negative or Pneu-Vac systems are best suited for conveying from several points to one. S-W systems are in use for all types of dry, pulverized and granular materials such as flour, feed, seeds, chemicals, plastics, etc.

ADHESIVES Powdered glue has been conveyed pneumatically by S-W systems, ground to the required mesh sizes in S-W size reduction machines, and mixed in a variety of S-W vertical mixing units. Mucilage, and ingredients such as casein are also processed in S-W unit machines.

ALUMINUM HYDROXIDE S-W Horizontal Single Ribbon Mixers with paddle agitators are used to mix finely powdered material with lump form of same material.

AMMONIUM NITRATE Conveyed from storage to mixers in S-W negative pressure systems. Although ammonium nitrate must be handled carefully because of its explosive qualities, it has been pelleted, reduced in size, and mixed in S-W equipment.

ATTRITION MILLS S-W Attrition mills grind, cut, shear, shred, pulverize, granulate, roll, crack, rub, curl, twist, hull and blend. S-W offers Single and Double Runner Mills with an endless variety of grinding plates designed by S-W engineers and cast in the modern S-W foundry.

* *Adaptioneering®... a unique creative engineering approach which translates the knowledge gained in one field to the solution of problems in another. The "A" section of a dictionary of products processed in SW unit machines is available on request.*

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Tubexperience in action

X ray checks a critical weld

Precision welds of hafnium and Zircaloy plate in a costly reactor component go under X ray at Superior's Nuclear Products Division

*Nuclear reactor components—complex structures, control rods and channels—made from the reactive metals are extremely difficult to fabricate and usually represent many thousands of dollars in material and labor. Each end product must undergo thorough X-ray examination. Since we usually consider even the smallest defect cause to reject the entire unit, the workmanship called for is necessarily of the highest caliber. In addition, Superior has developed unique welding methods, special equipment and fixtures to make possible such precise fabrication.

For example, our engineers have adapted the use of controlled atmosphere chambers for welding and can produce welds with complete penetration of the material. Other equipment, much of it special in design, includes hydraulic forming presses; machine tools for swaging, beading, flaring and expanding; five vacuum furnaces; pickling and rinsing equipment; high-pressure, high-temperature autoclaves for corrosion tests.

If you need specially fabricated components, whether for nuclear reactor installations or not, consult our Nuclear Products Division. For more information on our facilities and services, send for a copy of Data Memorandum #23. Superior Tube Company, 2011 Germantown Ave., Norristown, Pa.

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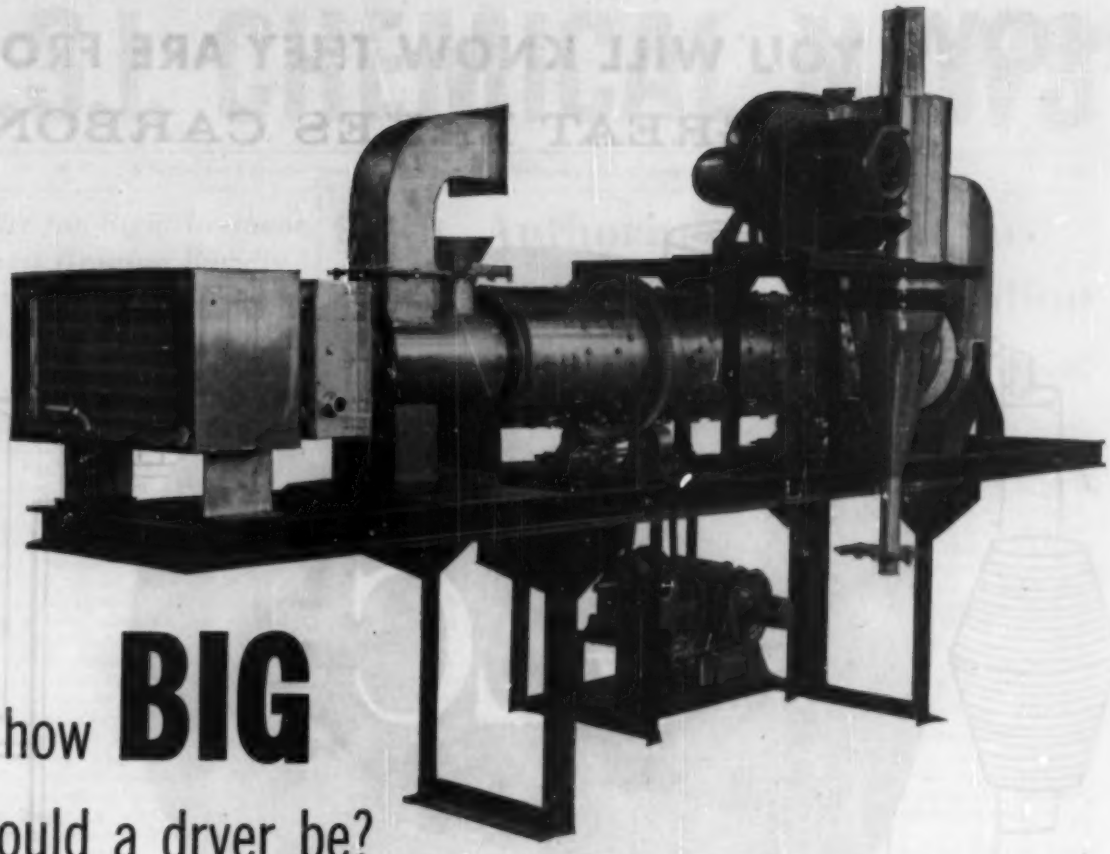

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"Baby" Louisville Dryers do a man-sized production job for chemical and pharmaceutical firms

Producers of pharmaceuticals and fine chemicals who buy or rent pilot-size Louisville dryers for on-site pre-production testing often find that the equipment produces sufficient quantities of processed material to supply the market!

Louisville Dryer engineers, utilizing our complete testing laboratory facilities assure you of getting the dryer type and size ideally suited to your needs. Every Louisville Dryer—large or small—is designed to fit the job and to give years of satisfactory performance at minimum cost.

Let Louisville's 61 years of drying experience work for you. A Louisville engineer is always available to help you with your drying problems, anywhere in the country. No obligation for this service, of course.

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U.S.I. CHEMICAL NEWS

Jan. ★ A Series for Chemists and Executives of the Solvents and Chemical Consuming Industries ★ 1959

Market for Rigid Urethane Foams Growing Rapidly

While rigid materials accounted for less than 10% of the total polyurethane foam market in 1957, 1958 figures are expected to show an increase to more than 20% of the total market. The Society of the Plastics Industry feels that by the end of 1959, 30-40% of the demand will be for the rigid foams.

The material is proving ideal for industrial and home insulation. Packaging applications are expanding. Makers of marine equipment are using the rigid foams for buoyancy. Military applications include radiation shields and heliohuts. More and more, structural panels and laminates are being made with rigid urethane foams.

Users can buy fabricated foam or they can foam the material themselves in place, by employing either molding or spraying techniques. Special equipment has been developed for spraying urethane polymer onto overhead, vertical or irregular surfaces. It foams and sets in place rapidly to give a rigid coat which will not slip, sag or fall away.

Rigid urethane polymers are formed by mixing two chemical components—polyisocyanates and polyesters. Carbon dioxide gas is given off during the reaction and it serves as a blowing agent which causes the polymer to foam in place. An intermediate that can be used to produce the polyester component is ISOSEBACIC® acid, a mixture of C-10 dibasic acids. ISOSEBACIC acid will be available soon in commercial quantities from a new U.S.I. plant at Tuscola, Illinois.

"Stabilized" Polyethylene Fabrics Now Being Made Via New Finishing Process

A patented technique for finishing polyethylene fabrics is now being employed to improve shrink resistance, strength, appearance and other physical characteristics. According to the patent, conventional finishing methods for polyethylene fabrics—calendering or hot fluid treatment of the greige goods to preshrink them—result in loss of yardage, strength and optimum appearance.

The patented process involves the pretreatment of oriented polyethylene filaments before conversion to give them a residual shrinkage of 8-20% (tested at 75°C for 20 minutes). The filaments are then converted to greige goods, in which they have a wavy form.

The greige goods are subsequently held along both the length and width to prevent retraction and are heated at a strictly controlled temperature for a limited time. So held and treated, the filaments in the fabric shrink to the extent of their residual shrinkage and straighten out, without reducing the area of the fabric.

By comparison with fabrics finished by conventional methods, these materials are said to have better appearance, strength and aging properties. The process is claimed to provide economies in operation — to save yardage and to reduce the number of finishing steps required.

Gov't. Authorizes Substitutions In SDA 40 Alcohol Formulation

Shortrge of Brucine Denaturant Made Modifications Necessary.

SDA 40, which the U. S. Government authorizes for use in toilet goods, external pharmaceuticals, biocides, detergents, etc., has been formulated until now with ⅛ gallon of *tert.*-butyl alcohol plus 3 ounces of brucine alkaloid or 3 ounces of brucine sulfate per 100 gallons of ethyl alcohol. To relieve difficulties of denaturers and users of this formulation due to a critical shortage of brucine, the Internal Revenue Alcohol and Tobacco Tax Division (A. & T. T. D.) has authorized the formulation of SDA 40 with ⅛ gallon of *tert.*-butyl alcohol plus either 1½ ounces of brucine alkaloid, or 1½ ounces of brucine sulfate, or 1½ ounces of quassin per 100 gallons of ethyl alcohol.

How the Substitutions Came About

When the brucine shortage first became acute, an inability to meet customer requirements for SDA 40 threatened to upset the entire industry. Recognizing the situation, the A. & T. T. D. authorized quassin as an alternate denaturant.

While brucine is one of the bitterest materials known, quassin had been tested and found sufficiently bitter and acceptable from other standpoints to serve as an alternate denaturant. Quassin had been used as a denaturant in Canada for 25 years, and this experience dispelled concern about possible adverse effects arising from its use.

Samples of SDA 40 denatured with quassin were offered to the trade, and users were urged to make up their products with this alternate, to assure compatibility with their formulas. After testing, many customers advised that they would accept SDA 40 alcohol with this denaturant.

However, realizing that limitations on the supply of quassin made it an incomplete answer to the shortage, the A. & T. T. D. took quick action to extend existing supplies of brucine by authorizing denaturation with reduced quantities of brucine alkaloid and

MORE

SDA 40 AUTHORIZED USES
(Under Permit)

- Hair and Scalp Preparations
- Bay Rum
- Lotions and Creams (Hand, Face, Body)
- Deodorants (Body)
- Perfumes and Perfume Tinctures
- Toilet Waters and Colognes
- Shampoos
- Soaps and Bath Preparations
- External Pharmaceuticals (not U.S.P. or N.F.)
- Disinfectants, Insecticides, Fungicides and Other Biocides
- Cleaning Solutions (including Household Detergents)
- Theater Sprays, Incense and Room Deodorants
- Miscellaneous Dye Solutions
- Miscellaneous Solutions

Vitamin C Indicated for Virus & Other Infections

Several medical investigators have found that continuous massive doses of ascorbic acid (Vitamin C) are effective in treating virus diseases such as polyiomyelitis, measles and virus pneumonia; bacterial infections such as tuberculosis and scarlet fever; and cases of poisoning such as snake bite and lead poisoning. The range of antibiotic and antitoxic action is said to be unusually broad, and, in addition, there is claimed to be *complete freedom from allergic or toxic reaction.*

Intravenous or intramuscular injection is the preferred method of treatment. When so administered, ascorbic acid is said to compare favorably with sulfa drugs and mycelial antibiotics. Effectiveness of the therapy is reported to be dependent upon the potent oxidation-reduction action of ascorbic acid, which rapidly neutralizes viral or bacterial toxins.

Ascorbic acid occurs naturally in citrus and other fruits, as well as green leafy vegetables. One method of producing it synthetically is by using L-sorbose as the starting compound and employing *sodium methoxide* in the final (enolization) step of the synthesis.

Index of Chemical Patents Now Being Prepared

Every patent relating to chemistry which has been issued by the U. S. Patent Office since 1950 is being collected and indexed for reference purposes by a Washington information service. The collection is being kept current and is being made available on a subscription basis to chemical companies, libraries, educational institutions and other interested organizations.

At the moment, indices for 1955, 1956, 1957 and the first 10 months of 1958 are available. They cover 30,000 patents. A trained staff of chemists and biochemists is now working on the indices for 1950-1954, which will add another 40,000 patents. It is estimated that when this work is completed, in about two and one-half years, more than 100,000 patents will have been collected and indexed.

It is claimed that the indexing method used analyzes, edits, classifies and cross-indexes U. S. chemical patents into the fastest and most accessible reference system ever devised.

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Jan. ★ **U.S.I. CHEMICAL NEWS** ★ 1959

CONTINUED *Alcohol*

brucine sulfate. Consequently, there are now three new SDA 40 formulations approved by the Alcohol and Tobacco Tax Division. U.S.I. designations are shown in the box below.

U.S.I. Designations for New SDA 40 Formulas

SD-40-1M .....1½ oz. brucine alkaloid
SD-40-2M .....1½ oz. brucine sulfate
SD-40-3 .....1½ oz. quassin

U.S.I. Studying Alternate Denaturants

Because brucine and quassin derive from natural imported products, there is always the possibility that the supply of these denaturants might be inadequate at some future date. U.S.I.'s research laboratories are therefore continuing studies to develop suitable additional alternates.

Ideally, alternate materials suitable as denaturants should be synthetic and domestically produced. Once found and tested in end-use formulations, such stand-by alternates—pending approval by the government—would assure denatured alcohol consumers of an uninterrupted flow of raw material at all times.

Methionine-Hormone Formulation Effective For Treating Acne

Clinical studies have revealed that a formulation of DL-acetyl methionine, estrogenic hormone, colloidal sulfur and resorcin applied to the skin is effective for treating acne conditions.

The medical research workers who conducted these studies found that methionine—the sulfur-bearing amino acid—and the estrogenic hormone act synergistically to reduce the excessive secretion of fatty materials from the sebaceous glands—a characteristic condition in acne cases. Consequently, the formulation dries and heals the acne lesions rapidly.

For optimum results, the treatment was supplemented with dietary and hygienic routines, and small oral doses of thyroid extract and estrogenic hormone.

Pure Sodium Alkoxides Can Be Made by Dry-Way Process

A new technical bulletin just released by U.S.I. describes a valuable but little-known technique for preparing sodium alkoxides from metallic sodium and alcohol vapors. This low-cost, dry-way process yields powders which are high-analysis alkoxide, in contrast to the 16-18% alkoxide solutions produced by the usual method of introducing sodium into liquid alcohols. It provides a way for pharmaceutical and other manufacturers who make their own alkoxides to get a high-purity material.

Products are almost identical in analysis to commercially available alkoxides. Although the bulletin describes the laboratory technique of passing vaporized alcohols over molten sodium, sufficient data is available to serve as a guide in designing a pilot plant.

Laboratory apparatus for dry-way preparation of sodium alkoxides.

TECHNICAL DEVELOPMENTS

Information about manufacturers of these items may be obtained by writing U.S.I.

L-Methionine, labeled with both carbon-14 and deuterium (methyl-$C^{14}D_3$), can now be obtained for research purposes. This amino acid is reported useful in studying the mechanism of ergosterol. **No. 1430**

Cosmetic technology is discussed in new, 1450-page book now being sold. In 53 chapters, 61 experts cover over 3 dozen types of products. Includes technology, historic and legal aspects, physiology, testing, manufacture. **No. 1431**

Slide rule for chemists has special scales for solving pressure, temperature, solution concentration problems on one face, standard scales on other face. Gives atomic wts. of 52 elements, molecular wts. of 18 atomic groups. **No. 1432**

Chloromethoxypropyl mercuric acetate solutions now available in commercial quantity. Fungicidal and bactericidal activity claimed superior to phenyl mercuric compounds. Due partly to presence of labile chlorine atom. **No. 1433**

Uses of stainless steel in CPI discussed in newly revised, 40-page free booklet. Sections on fields of plastics, detergents, nuclear power, others. Includes corrosion resistance table and table comparing stainless grades. **No. 1434**

Full line of polyesters for producing rigid or flexible urethane foams can now be obtained commercially. For rigid products, combinations of prepolymer and polyester are offered for foaming in place by mixing or spraying. **No. 1435**

Long-path infrared system recently developed is said to detect evaporation from one drop of a predetermined chemical in an average room. System senses the chemical by its IR spectrum, is not usually sensitive to other materials. **No. 1436**

Polyethylene work gloves now on market are claimed to provide protection without loss of fingertip sensitivity. Are lightweight, waterproof, resistant to most chemicals. Said to be suitable for use with radioactive materials. **No. 1437**

Comprehensive file of trademarks used by CPI here and abroad is now available for reference at a charge. Includes registered, unregistered, common, scientific, technological names. Composition, uses, producer given in many cases. **No. 1438**

New analytical-grade ion-exchange resins based on cellulose are claimed suitable for chromatographic fractionations of high-molecular-weight materials beyond range of conventional resins. Are extremely porous and hydrophilic. **No. 1439**

PRODUCTS OF U.S.I.

ALCOHOLS

Ethyl Alcohol (Ethanol): Specially denatured — all regular and anhydrous formulas. Completely denatured — All regular formulas for industrial use, anti-freeze. Pure alcohol—USP 190°—Absolute, N.F., taxfree, taxpaid.

Proprietary Denatured Alcohol Solvents: SOLOX® — General-purpose. FILMEX® — Special, authorized for certain industries. ANSOL® M — Anhydrous, special blend for lacquers, resins, etc. ANSOL® PR—Anhydrous, special blend with higher ester content and solvency for lacquers, resins, etc.

OTHER PRODUCTS

Organic Solvents and Intermediates: Normal Butyl Alcohol, Amyl Alcohol, Fusel Oil, Ethyl Acetate, Normal Butyl Acetate, Diethyl Carbonate, DIATOL®, Diethyl Oxalate, Ethyl Ether, Acetone, Acetoacetanilide, Acetoacet-Ortho-Chloranilide, Acetoacet-Ortho-Toluidide, Ethyl Acetoacetate, Ethyl Benzoylacetate, Ethyl Chloroformate, Ethylene, Ethyl Sodium Oxalacetate, Sodium Ethylate, ISOSEBACIC® Acid, Sebacic Acid, Urethan U.S.P. (Ethyl Carbamate), Riboflavin U.S.P., Pelargonic Acid, 2-Ethyl Heptanoic Acid.

PETROTHENE® Polyethylene Resins

Pharmaceutical Products: DL-Methionine, N-Acetyl-DL-Methionine, Urethan USP, Riboflavin USP, Intermediates.

Heavy Chemicals: Anhydrous Ammonia, Ammonium Nitrate, Nitric Acid, Nitrogen Fertilizer Solutions, Phosphatic Fertilizer Solution, Sulfuric Acid, Caustic Soda, Chlorine, Metallic Sodium, Sodium Peroxide, Sodium Sulfite, Sodium Sulfate.

Animal Feed Products: Antibiotic Feed Supplements, BHT Products (Antioxidant), Calcium Pantothenate, Choline Chloride, CURBAY B-G®, Special Liquid CURBAY, VACCITONE®, Menadione (Vitamin K_3), DL-Methionine, MOREA® Premix, Niacin USP, Riboflavin Products, Special Mixes, U.S.I. Permadry, Vitamin B_{12} Feed Supplements, Vitamin D_3, Vitamin E Products, Vitamin E and BHT Products.

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SCOPE

Engineering Salaries Continue to Advance

Median yearly earnings of all engineering graduates in the U. S. increased from $6,500 in mid-1953 to $8,750 in mid-1958, at a steady rate of about 6.5 percent a year.

This is the overall conclusion of a study on "Professional Income of Engineers" to be published this month by the Engineers Joint Council. The study, which covers in detail the years from 1956 to 1958, is the third of a series, the first two of which were published in 1953 and 1956.

While engineering earnings, therefore, increased by 13% between 1956 and 1958, the consumer price index rose 1.5 percent in the same two-year span, and the average gross weekly earnings for production (manufacturing industries) rose about 10%. The increase in engineering earnings was not distributed equally among the various activity classifications in the survey, or among the experience levels. Industry increases, however, paralleled closely the overall average increments.

Government increases, on the other hand—for both absolute dollars and percentages—were above the averages. This reflects the notable advances which the Government agencies have obtained during the last two years, particularly the flat increase granted by Congress in 1958 for Civil Service engineers in the Federal Government.

This relative rise above industry increments, however, has not placed Government employment in a competitive salary position with industrial employment. Earnings of engineers in Government were shown by the survey to lag most seriously behind industry at experience levels beyond 12 years: beyond this point, the 1958 Government medians are far below the 1958 industry medians. For example, median 1958 earnings for engineers who got their degrees in the period 1930-1934 were $11,350 in industry as against $9,325 in Government.

The complete published survey will include 41 tabular and graphic presentations: comparison of medians for 1953, 1956, and 1958; all activities combined; all industries with 26 subdivisions; all levels of Government with subdivision of Federal, State, and Local; college teachers—teaching salaries and total income; technical institute teachers-teaching salaries and total income; engineering societies and magazine staffs.

The information tabulated in the new 1958 study is based on survey returns from 190,180 engineering graduates. Of these, 155,124, comprising 81.3% of the total sample, were employed in industry by some 546 different companies. Federal, State, and Local governments employed 30,028 engineers in 131 agencies (15.7% of sample). Finally, education, including the engineering colleges, technical institutes, and engineering societies and magazines, employed 5,658, or 3.0% of the sample.

In the industrial sector of the survey, heaviest representation was in the electrical machinery & electronics manufacturing industry, in which 42,643 engineers reported earnings. Second was aircraft manufacturing with 26,133. In third and fourth places were the petroleum and chemical industries, with 13,798 and 12,880 engineers respectively.

1958 Median Earnings for Engineering Graduates by Year of Entry Into Profession (Baccalaureate Year)

Year	All Activities Combined (190,810 Engineers)	Industry (155,124)	Government (30,028)	Engng. College Teachers (5,139)
1958	$5,850	$5,925	$5,350	$5,600
1957	6,125	6,175	5,675	5,425
1956	6,475	6,525	6,075	5,700
1955	6,800	6,850	6,400	5,950
1954	7,000	7,050	6,700	6,225
1953	7,400	7,450	6,850	6,400
1952	7,700	7,725	7,075	7,100
1951	8,050	8,125	7,675	7,425
1950	8,350	8,450	7,775	7,500
1949	8,700	8,825	8,050	8,275
1947-48	9,200	9,325	8,325	8,625
1945-46	9,450	9,675	8,250	8,950
1940-44	10,250	10,450	9,050	9,875
1935-39	10,825	11,300	9,225	10,650
1930-34	10,675	11,350	9,325	10,850
1925-29	11,050	11,225	9,575	10,050
1920-24	11,200	11,850	9,425	10,650
1915-19	10,675	11,000	9,350	9,950
1914	9,500	11,000	9,225	9,175
Nos. Earning $20,000 and Over	3,313	3,125	10	161
Nos. Earning Less than $5,000	1,530	601	735	185

SCOPE

Two-fold Presidential Action on Science Front

Eisenhower sets up Science Research Council, directs establishment of Science Information Service

The President has acted in two directions to increase coordination of Government research programs and to strengthen the American scientific effort. The first step came with a Presidential directive to the National Science Foundation ordering the establishment of a Science Information Service within the Foundation. Step number two was the creation of a Federal Council for Science and Technology, to be headed by James R. Killian, Jr., who is presently the President's special assistant for science and technology.

The newly-created Federal Council, establishment of which had been recommended by the President's Science Advisory Committee, will be made up of officials of Government agencies involved in research and development. Hope of the new Council, is, according to the President, "that it will improve the planning and management of Government research programs, will facilitate the resolution of common problems, and promote greater interagency cooperation."

Science Information

The President's action in directing the NSF to set up a Science Information Service seems to settle once and for all a question which has agitated the American scientific community for some time. Stated simply, the question was this: to secure maximum efficiency in the rapid dissemination of new scientific information, would it be better to set up a large, highly centralized agency, financed by the Federal Government, with or without the support of private industry; or would it be more realistic to establish a service of the coordinating type, which would take advantage of existing organizations and the specialized skills of persons with long experience in the field?

The first alternative, which approximates the policy which the Soviet Union has adopted, with certain evident success, would not, it was pointed out, necessarily be equally adapted either to our form of Government or to our traditional industrial structure. The Russians were not in a position to call upon the services of scientific information organizations such as are already in existence within the American private enterprise system. Thus, the role of the newly-created Science Information Service will be a coordinating one; it will strengthen rather than supplant existing agencies and facilities. Key functions of the new service will be:

Coordinate the effort of public and private agencies to afford immediate relief to short-term problems of a pressing nature;

Support a fundamental, long-term program of research and development, looking to the application of modern scientific knowledge to the over-all problem by application of machine techniques, etc.

Provide financial assistance where needed for publication of scientific journals and monographs. This would include encouragement of experiments with new and streamlined methods of publication designed to increase efficiency, improve service, and decrease costs.

Expand translation of Russian scientific literature to provide full coverage. Additional translation programs in Japanese and other languages will be initiated as needed.

Seek to expand and improve interlibrary exchange agreements throughout the world.

Washington notes

Thirty-seven-year-old Herbert F. York, chief scientist of the Advanced Research Projects Agency, has been appointed to the new position of Director of Defense and Engineering. . . . *Certain Washington sources are predicting* that the ARPA will get an extension of life beyond the present legal expiration date in March. . . . *It is reported* that a substantial expansion of the Naval Propellant Plant at Indian Head, Md., is in the works. . . . *AEC is said to have received* 107 *proposals* from 39 firms to provide services and facilities, and to perform research and development in connection with its Fuel Cycle Development Program.

J. L. Gillman, Jr.

Reinforced plastic sales volume up in 1958

Estimated figures from the Society of the Plastics Industry show total sales of 185 million lb. in 1958, up about 10 percent over 1957. Predicted gain for 1959 is 15 percent.

Chemical sales seen overtaking motors

"Chemicals are crowding the automotive industry for fourth place in sales in the nation's economy," said O. V. Tracy recently. The Standard Oil VP showed that the chemical industry has moved ahead of steel and is fast catching up with motors. Food, machinery, and oil are the only other industries with annual sales volumes exceeding the chemical industry's, he said.

SCOPE

Russian Technical Literature Evaluated

There is no noticeable statistical difference in the quality of American and Russian published technical literature in chemical engineering or in the general field of applied physical chemistry, according to the results of an extensive survey carried out recently under the direction of H. E. Hoelscher of Johns Hopkins.* In the field of practical engineering applications, however, indications are that the quality of published Russian papers is 10 to 20 years behind that of comparable papers published currently in U.S. technical journals.

The survey of Russian technical literature carried through by Hoelscher and his associates was based on 1,144 published articles on distillation and related subjects. All articles came from the technical publications of the Soviet Union, including the Ukraine, and not from the satellite countries. Fundamental articles on chemical engineering science were rated on a scale ranging from 0, which indicated that the article would not be published in the U.S., to 10, which meant that it was top-grade material, acceptable to any of the highest-ranking U.S. technical journals. On the other hand, articles dealing with applied engineering were evaluated on a qualitative basis by a group of American engineers experienced in the field.

Nearly 200 Russian journals were combed for suitable articles for evaluation purposes. About 75 percent of those selected came from about 10 leading chemical engineering publications. Of the Russian articles, some had already been translated, others were translated expressly for the survey by Hoelscher and others. As a control for comparison, some 500 American articles were evaluated by the same standards as the Russian.

Results of the survey were twofold, says Hoelscher. First, a practical and flexible rating system for technical papers was evolved, which would permit the setting up of a permanent running evaluation system. Second, these were the tangible results of the comparison of Russian and American chemical engineering literature—their apparent equivalence in the more fundamental theoretical area, the apparent American superiority in the field of applied engineering. It should be brought out, emphasizes Hoelscher, that the inferiority of Russian articles in the applied field is a matter of content, not of scientific competance or of technical reporting. For example, he points out, the Russians seem at the moment to be greatly concerned with vapor velocity in distillation columns, a subject which, in this country, would be considered more or less "old stuff."

An interesting point which came to light in the course of the survey was that, in the Russian articles in the theoretical domain, there was found extensive reference to articles in American and other Western technical journals. In the applied engineering articles, on the other hand, such reference was almost nil. Interesting, also, was the almost complete neglect of applied statistics as applied to practical engineering problems—a curious circumstance in view of the fact that Russian work in the theory of statistics is believed to be at least on a par with that of the West.

** A detailed report of the survey was given at the recent Cincinnati A.I.Ch.E. Annual Meeting in a paper titled Survey of Russian Literature in Distillation and Related Topics, H. E. Hoelscher, W. C. Bastian, and S. K. Friedlander.*

Big Soviet push in automatic control engineering

The Russian concentration of effort in the automatic control field seems to be following the same priorities as their general program of industrial development, reported William E. Vannah, editor of *Control Engineering*, speaking at the December A.I.Ch.E. Annual Meeting in Cincinnati. According to Vannah, recently returned from the Soviet Union where he was one of a group of control experts who had the opportunity to inspect a wide sector of the Russian instrument industry, the chemical industry is fifth on the priority list. It follows power, steel, petroleum, and heavy machinery, in that order. In the chemical industry itself, first installations of modern control instruments have been in synthetic rubber, aluminum, and the ammonia field, said Vannah. In the plastics plants inspected, the speaker's impression was that the Russians, at least in this sector, are a considerable distance behind current U. S. practice. Interesting to the visiting group was the fact that many Russian instruments now in production seemed to closely resemble standard American models made by such firms as Perkin-Elmer, Foxboro, and Leeds and Northrup. Vannah's conclusion—although the Russians are perhaps behind in certain aspects of control instrumentation, they are moving up fast, and there is no room for complacency on our part.

Line of least resistance

Experiments are reported to be under way in Upper Michigan to dewater iron ore by introduction of an electrical potential across an ore bed. The water is said to flow along the direction lines of the applied potential.

SCOPE

1958 Chemical Sales Could Pass 1957

"Preliminary year-end returns indicate that 1958 chemical sales could match or edge past the all-time high of $23.418 billion set in 1957," says a summary report just released by the Manufacturing Chemists' Association.

Highlights of the MCA roundup:

Sales—Latest figures for December point to total yearly sales of between $23.3 and $23.7 billion for 1958.

Profits—Down somewhat from 1957. For the first three quarters, profits after taxes averaged 6.7 percent of sales. Overall 1957 figure was 7.8 percent.

Production—Index for chemicals and allied industries averaged 182 through October. Preliminary October figure is 188, up over previous high of 186 for August, 1957.

Inventories—High for 1958 was $3-.877 billion in March. October is estimated at $3.747 billion. Decrease is attributed to increase in monthly sales rate.

Prices—Price line has held steady. Wholesale index (preliminary) for October, 1958, was 110.3; comparable figures for October, 1957, was 110.4. Index for all commodities other than food and farm products stood at 126.4 in October, 1958.

Assets—Total assets of chemical and allied products industries were $20.15 billion at the end of the third quarter of 1958. Assets at end of 1957 were $20.15 billion.

Profits on Assets—Profits after taxes as percent of assets are estimated at 7.5 percent for 1958, down from 8.8 percent for 1957.

Capital Expenditures — New plant and equipment outlay was down to $1.338 billion (estimated) in 1958 from $1.724 billion in 1957.

Employment — Down from 1957. Average through November, 1958, was 821,000. Average for 1957 was 844,000.

Research—Total R & D expenditure for the chemical and allied industries for 1958 is estimated at $560 million, is expected to pass the $600 million-a-year mark by 1960 according to some industry sources.

Construction bids out for United Engineering Center

Plans have gone out for bids to seven large construction firms for erection of the new United Engineering Center on United Nations Plaza in New York. Ground-breaking ceremonies are scheduled for April of this year, construction is expected to start in July. Final completion of the building is now seen by early 1961. . . . Closing date for the Member Gift Campaign has been extended to allow sufficient time for each society to meet its quota. A.I.Ch.E. still leads the race with an estimated 78 percent of its quota already subscribed. . . . Direction of the Industry Campaign passes into hands of M. J. Kelly, president of Bell Telephone Laboratories, as of January 1, 1959.

First nitrogen fertilizer plant for Iran

A 140-mile pipeline will bring natural gas from the petroleum fields at Gashsaran, Iran, to Shiraz, where a 100 metric ton-day ammonia plant will be the heart of the country's first nitrogen fertilizer plant. Montecatini, Milan, Italy, has been appointed general advisor to the Iranian government for the project, and a Montecatini process will be used for ammonia production. Equipment procurement and plant construction will be done by ENSA, a French-British consortium, which owns the Gashsaran oil fields. Total project cost is estimated at $30 million.

First computer-controlled chemical plant seen in 1959

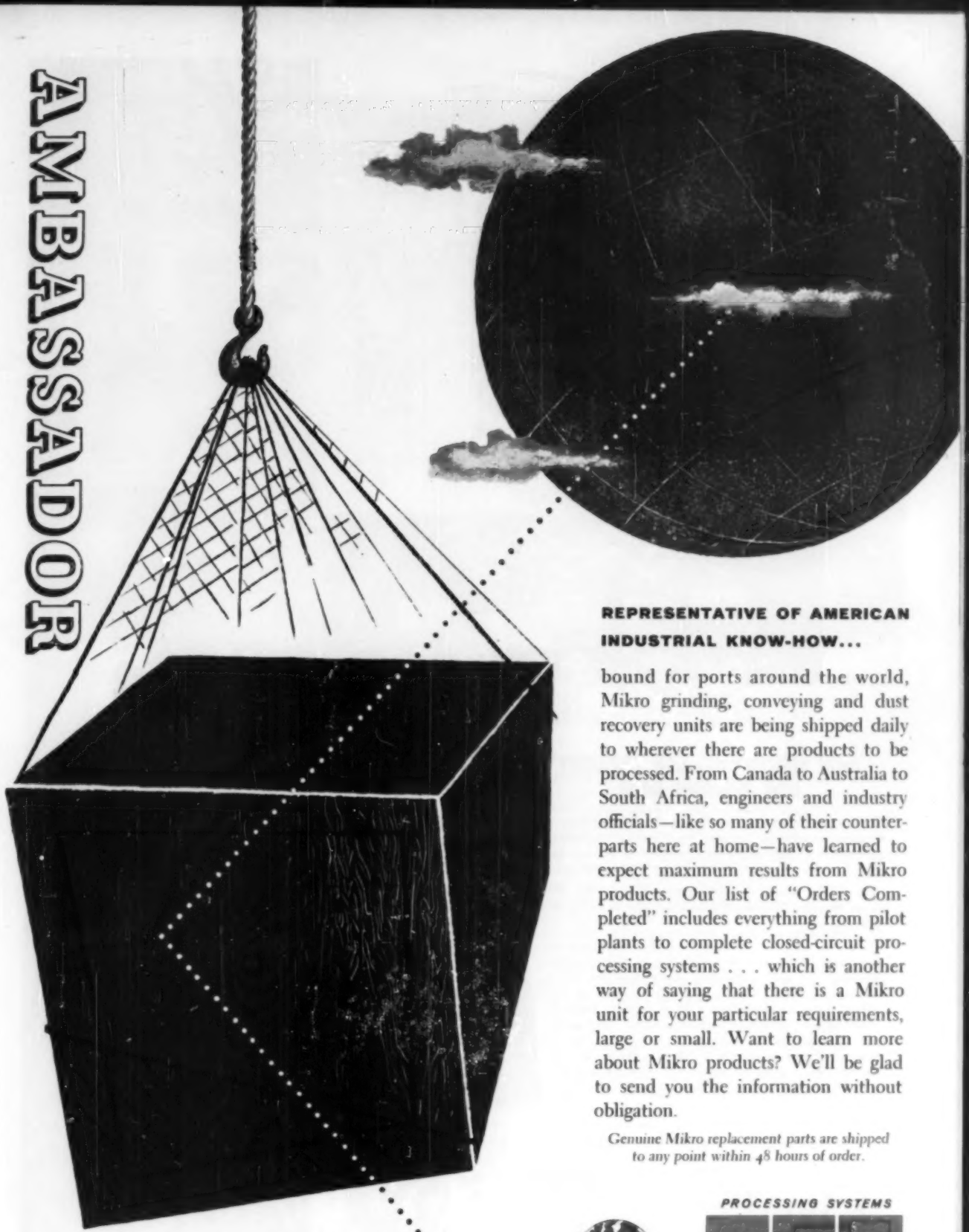
The "first chemical plant to use an electronic computer for the direct, on-line control of the over-all process" will be on stream in 1959, says Monsanto Chemical. Plant location and process involved have not been disclosed. Control unit will be a RW-300 Digital Control Computer, made by Thompson-Ramo-Wooldridge Products Co.

From Here and There

A new ethylene plant, first of several units to be completed as part of a major expansion program of Jefferson Chemical, is on stream at Port Neches, Texas. . . . *Polyethylene will be made in Belgium* by Cobenam, S.A., a new company jointly owned by Union Carbide and the Belgian company, Societe Chimique des Derives du Petrole (Petrochim). . . . *Sole North American agent for chemical process developed* and owned by the German engineering firm of Josef Meissner, Cologne, will by Girdler Construction Division, Chemetron Corp. . . . . *A new type of corn* "with extraordinary possibilities in the production of new types of starches" is jointly announced by National Starch Products, Inc., and American Maize-Products Co. . . . *A research contract for work on propellants* has been signed by Monsanto with the Navy's Bureau of Ordnance.

For more information, circle No. 50 ➤

AMBASSADOR



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bound for ports around the world, Mikro grinding, conveying and dust recovery units are being shipped daily to wherever there are products to be processed. From Canada to Australia to South Africa, engineers and industry officials—like so many of their counterparts here at home—have learned to expect maximum results from Mikro products. Our list of "Orders Completed" includes everything from pilot plants to complete closed-circuit processing systems . . . which is another way of saying that there is a Mikro unit for your particular requirements, large or small. Want to learn more about Mikro products? We'll be glad to send you the information without obligation.

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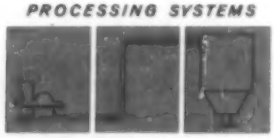
SPAN THE GLOBE

PROCESSING SYSTEMS



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REPRESENTATIVES throughout the United States, Continental Europe, British Isles, Canada, Mexico, Central and South America, West Indies, South Africa, India, Japan, Philippines, Australia and New Zealand.

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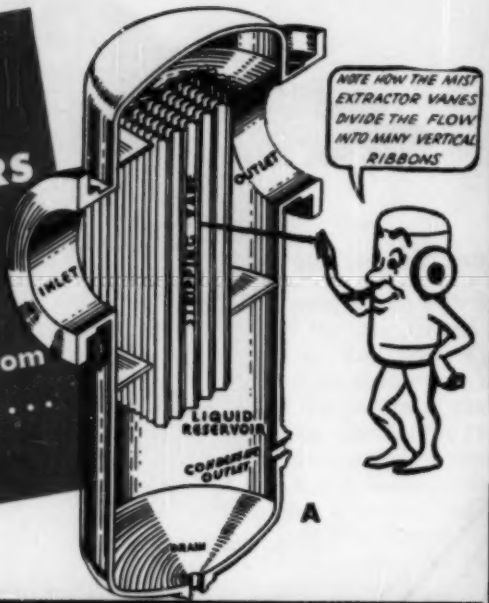
PEERLESS LINE SEPARATORS

Outstanding for the efficient extraction of liquid mist from gas or steam . . .



A

FLOW
TOP VIEW
MIST COLLECTS INTO DROPS ON THE WET SURFACES
DROPS IMMEDIATELY ENTER DEEP POCKETS OUT OF GAS FLOW
BI-DIRECTIONAL CHANGE SIDE TO SIDE IN LIQUID SEPARATION
TURBULENCE CAUSES EVERY MIST PARTICLE TO CONTACT STRIKING VANE SURFACES
GAS IS STRIPPED DRY LONG BEFORE REACHING END OF VANES

B

HIGH EFFICIENCY—HIGH CAPACITY LOW PRESSURE DROP

Thousands of installations throughout the Refining and Chemical industry have proven the Peerless Line Separator principle to be one of the most outstanding methods available for the extraction of liquid from gas, steam or air.

Drawing A above shows the arrangement of the vanes in the Separator. Drawing B is an illustration of the Peerless principle.

The mist extractor combines the forces of impingement, centrifugal motion and surface tension to obtain its high efficiency. The path of the gas, etc., through the unit is constantly bending, causing semi-violent turbulence and rolling of the gas against the walls of the vane. Impingement and centrifugal force combine to contact the droplets with the vanes, where they coalesce, and surface tension then causes them to cling to the vanes' surfaces. Gravity and the impact of the gas stream then drives the droplets into the pockets where they roll down the vanes and out of the gas stream.

Through the Peerless method of mist extraction, the gas is stripped dry long before reaching the end of the vanes.

there's A PEERLESS SEPARATOR FOR EVERY REQUIREMENT

For any capacity
For any working pressure
For corrosive conditions
With removable vane units
With extra body length
With connections for accessory equipment
For pressure drop requirements of less than 6" water
For any vapor-liquid ratio
For any piping requirement

SPECIAL DESIGN SEPARATORS FOR ANY REQUIREMENT

FOR FURTHER INFORMATION ON THE USE OF PEERLESS LINE SEPARATORS PLEASE WRITE FOR NAME OF NEAREST PEERLESS ENGINEER.

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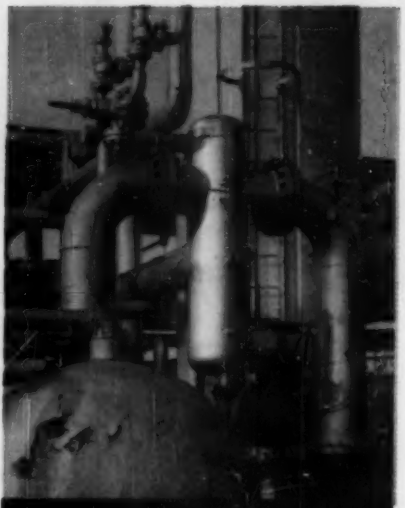
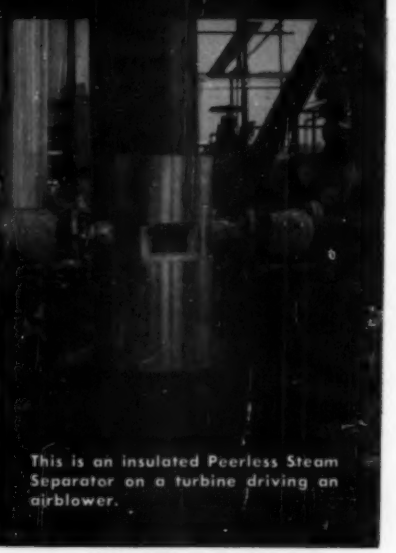


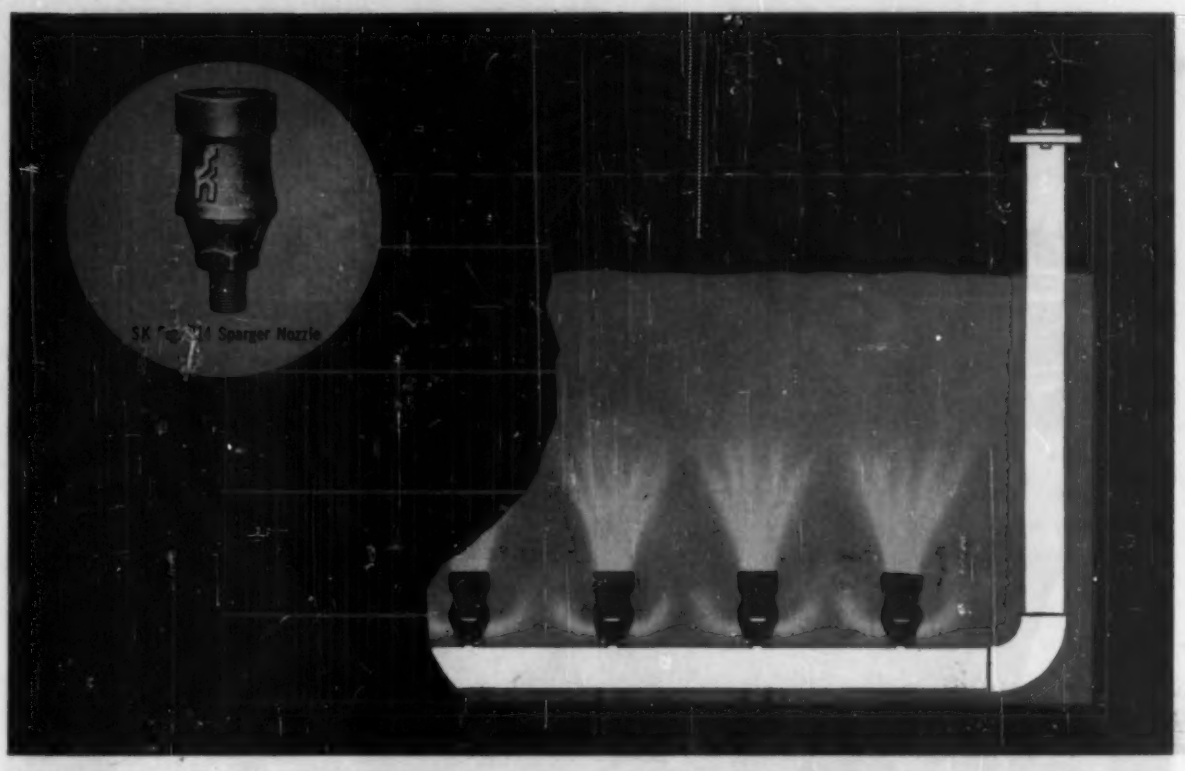
A Peerless Line Separator is shown above removing entrainment from a refinery reboiler.

Peerless Line Separators are doing an effective job of mist extraction at this Kentucky Petrochemical Plant.



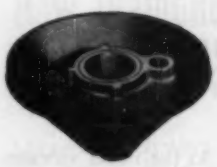
This is an insulated Peerless Steam Separator on a turbine driving an airblower.

For more information, turn to Data Service card, circle No. 51



HOW TO HEAT AND AGITATE LIQUIDS IN TANKS

efficiently, economically, and with less noise



SK Fig. 301 Noiseless Heater for Tank Heating

SK Fig. 315 Circulating Heater for Tank Heating

SK Fig. 320 Continuous Heater for Pipe-Line Heating

SK Fig. 327 Slurry Heater for Pipe-Line Heating

Do it with plant steam and SK Steam Jet Heaters.

These Heaters utilize the jet principle to mix steam with a cold liquid, uniformly and without the noise and vibration usually associated with such operations. Since all of the heat in the steam is absorbed by the tank liquid being heated, operation is efficient. Because the jet action of the Heaters produces agitation and circulation, you need no additional equipment to perform these functions. Furthermore, since Steam Jet Heaters have no moving parts (except an adjusting spindle on some pipe-line types), you get long, trouble-free service without costly supervision and maintenance.

The illustration above shows tank heating being accomplished using SK Sparger Nozzles—one of the several types of Heaters offered by SK. Units of this type are ideal for use where uniform agitation is required over a large shallow tank area. In operation, a jet of steam issuing through the nozzle entrains tank liquid through the suction opening. Condensation takes place immediately upon mixing of liquid and steam and the stream of heated liquid is discharged at considerable velocity providing constant agitation.

Several other types of SK Steam Jet Heaters—for both tank and pipe-line heating—are shown at left. Complete details on all types are contained in Bulletin 3A which is available on request.

JET APPARATUS: Ask for Condensed Bulletin J-1.
ROTAMETERS & FLOW INDICATORS: Ask for Condensed Bulletin M-1.
VALVES: Ask for Condensed Bulletin V-1.
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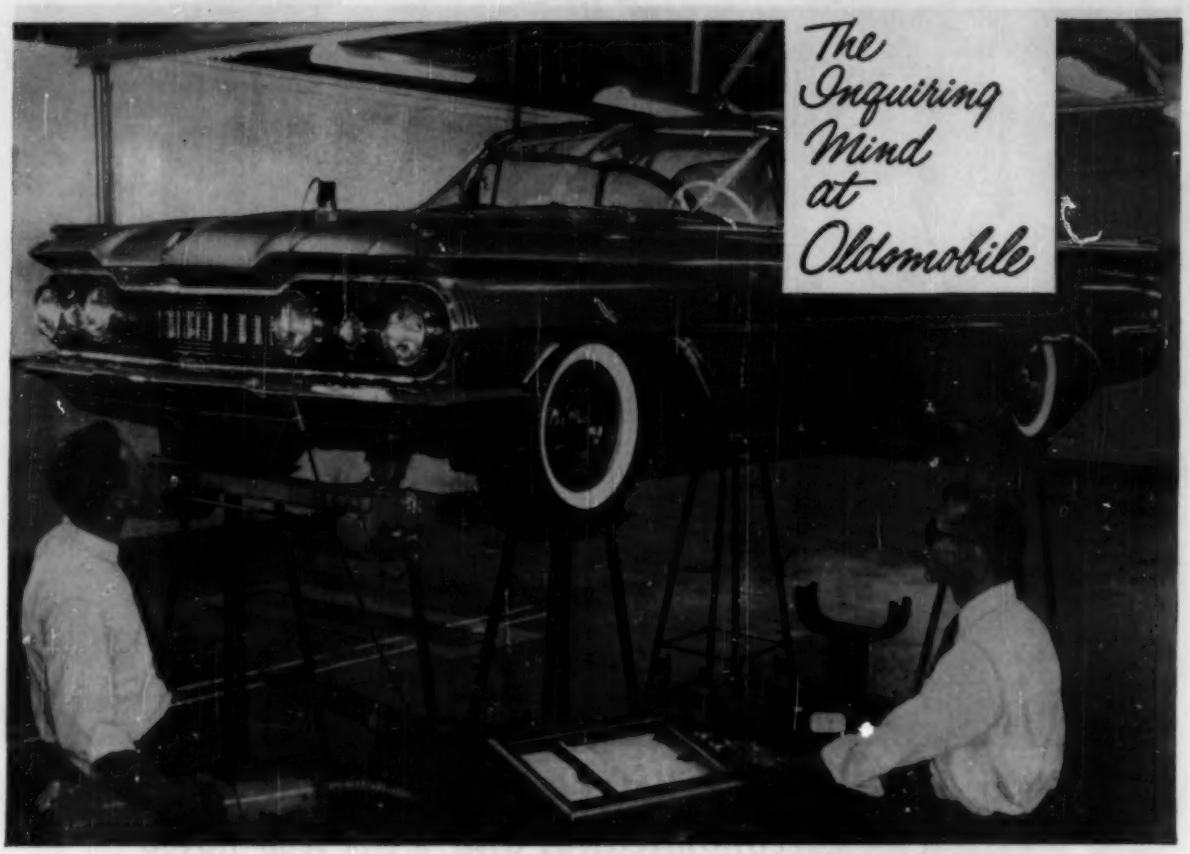

no. 7 OF A SERIES

A "SOUND" APPROACH TO RIDING COMFORT

The "tuning out" of excessive shake and vibration by Oldsmobile engineers produces a comfortable, balanced ride that adds thousands of miles to the life of an automobile.

One of the most critical areas of engineering in today's automobile is "ride". It is critical because an unsatisfactory ride means an unsatisfactory automobile. To produce an over-all balanced and smooth ride, free from harshness and fatiguing vibration, Oldsmobile engineers begin the complex task of "tuning" the car in the early stages of a new model program. Not only is ride important from the comfort standpoint, but an improperly "tuned" car can literally shake itself apart after several thousand miles.

The tuning operation is a series of intricate tests that determine a car's "shake" characteristics—where and how much the metal bends and twists. To produce beaming and torsional moments, a mechanical oscillator is attached to the frame and vibrates the car in a frequency range of 7½ to 15 cycles per second. To measure the displacement of the metal, a velocity pick-up is attached directly to the area under study. As the metal vibrates, a signal is produced by the pick-up and is fed to a vibration meter where it is integrated. The resulting signal is then transmitted to an X-Y plotter that instantly converts it into a continuous magnitude-vs.-frequency trace.

With this valuable information, refining can begin by altering the structure of the various component parts. A complex network of infinite variation must be analyzed intensively to produce the mark of quality that stamps every Oldsmobile.

Over the years, Oldsmobile's reputation for quality manufacturing and precision engineering has grown, step by step, until today it is a car of recognized distinction—in a class by itself. Oldsmobile's durability and long service life is further attested to by its continued leadership in resale value. You owe it to yourself to first examine, then test-drive, a truly outstanding automobile—the 1959 Oldsmobile. Visit your Local Authorized Oldsmobile Quality Dealer as soon as possible.

OLDSMOBILE DIVISION, GENERAL MOTORS CORPORATION

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Pioneer in Progressive Engineering ...Famous for Quality Manufacturing

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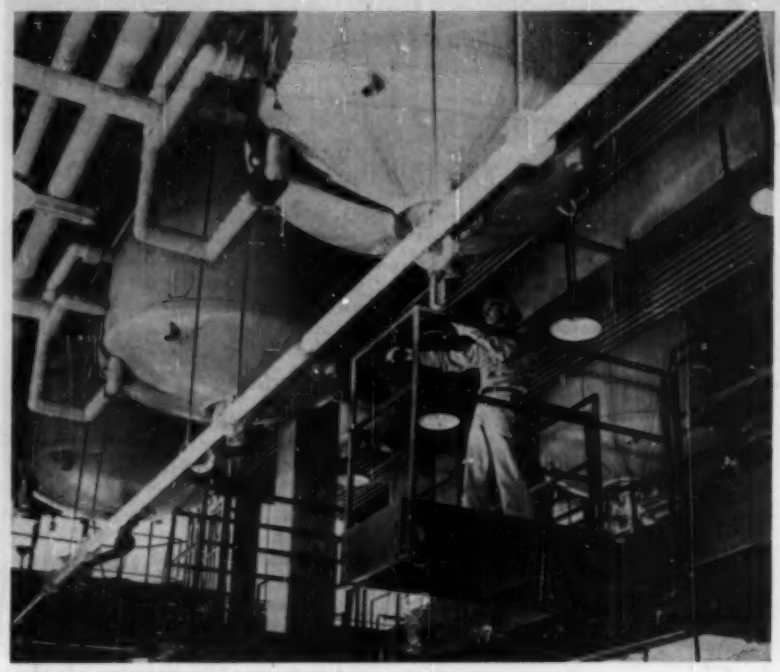
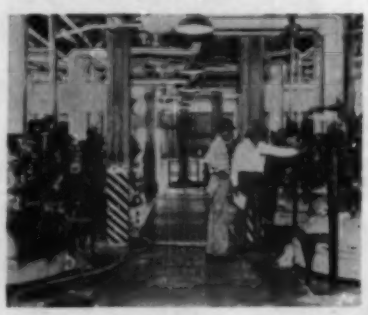
PFAUDLER
CORROSIONEERING NEWS



How Diamond Alkali uses Glasteel to cut turn-around time and protect purity at its PVC plant

Like most polymers, polyvinyl chloride gets so sticky in process that it gums up equipment surfaces to the point that a general clean-out is usually required after each batch.



Wishing to avoid such unproductive, unprofitable time at its new Deer Park, Texas plant, the Diamond Alkali Company instructed its engineers to run comparative tests on materials of construction.

Pfaudler Glasteel was the final choice and Diamond Alkali uses it wherever possible in the new plant . . . for polymerizers, blow-down tanks, storage and receiver tanks, and even for pipes and valves.

So little of the PVC clings to the smooth glassed surfaces of this equipment, a simple fast flush is all that's necessary to keep it in process condition.

During two years of operation, on a twenty-four hour a day basis, production has been halted only for routine maintenance.

Protects purity too

Pfaudler Glasteel is chemically inert to the ingredients and catalysts used in making PVC . . . so there can never be any contamination of Diamond Alkali's product.

Special agitator seals on the polymerizers prevent any lubricants from bleeding into the product.

The equipment is so designed and controlled that Diamond Alkali can hold temperatures to within ½° F. of a desired setting.

If you would like to know more about Pfaudler Glasteel and the equipment made with it, check the coupon for our Bulletins 968 and 932.

Big zirconium and titanium heat exchangers now available

Recent addition of vacuum-purge inert gas welding to the already established flow-purge inert gas welding chamber shown below, places Pfaudler in the advantageous position of offering the most advanced facilities for welding the highly corrosion-resistant metals, titanium and zirconium. Now several hundred square feet of heat transfer surface can be more economically and rapidly produced.

Add these metals to your list of available Pfaudler materials for fighting corrosion in process equipment—a growing list that already includes Glasteel, stainless steel, Hastelloy, nickel, Inconel, and Monel.

The unit being worked on in the picture is one of the largest zirconium exchangers built to date, having 134 square feet of heat transfer area. Sixty-four 1" O.D. 18 gauge seamless zirconium tubes in a 21" O.D. shell 8' long. Designed for 75 psi and 350°F., it forms the calandria section of an evaporator for concentrating hydrogen peroxide solutions.

For bulletins describing our complete line of heat transfer equipment, check the coupon below.

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Please send me ☐ Bul. 968 and 932, Buyer's Guide; ☐ Bul. 949, Metal and Alloy Heat Exchangers; ☐ Bul. 921 and 968 on Glasteel Heat Transfer Equipment.

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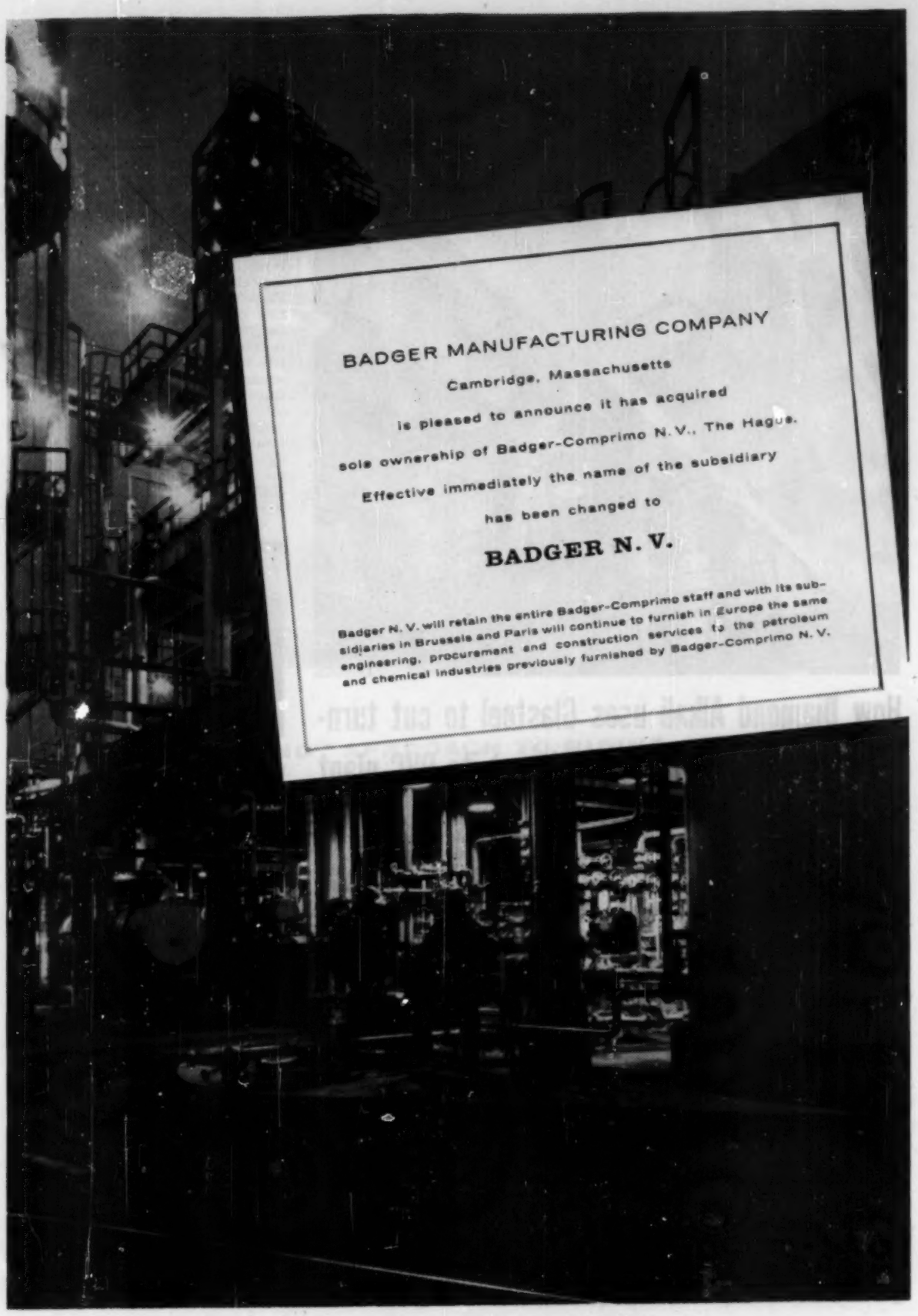
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is pleased to announce it has acquired
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BADGER N. V.
Badger N. V. will retain the entire Badger-Comprimo staff and with its subsidiaries in Brussels and Paris will continue to furnish in Europe the same engineering, procurement and construction services to the petroleum and chemical industries previously furnished by Badger-Comprimo N. V.

For more information, turn to Data Service card, circle No. 5

Progress Report...

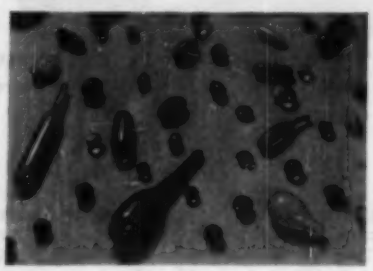
– 2-Methyl pentaldehyde
– Epoxy resins
– Butanol
– Metal-drawing compounds

Isomerically-pure, six-carbon aldehyde

CARBIDE is now offering commercial quantities of 2-methyl pentaldehyde. This colorless liquid is almost insoluble in water, though miscible with ethanol and other organic solvents.

2-Methyl pentaldehyde boils at 118.3°C. at atmospheric pressure. It sets to a glass below –100° C. Its solubility in water is 0.42% by weight. Molecular weight is 100.16.

2-Methyl pentaldehyde is easily oxidized to 2-methyl pentanoic acid or reduced to the corresponding alcohol. It can be condensed with itself or other aldehydes to form esters, aldols, and higher condensation products. In reaction with formaldehyde followed by hydrogenation of the reaction product, 2-methyl-2-propyl-1,3-propanediol is obtained. This diol is an intermediate in the preparation of meprobamate tranquilizers.



Since 2-methyl pentaldehyde contains a reactive carbonyl group, it is easily converted to cyanohydrin, hydroxy acid, acetal, or to other organic compounds. This method of reaching such compounds should be evaluated in the synthesis of pharmaceuticals, plasticizers, rubber chemicals, dyes, resins, and insecticides.

2-Methyl pentaldehyde is supplied by CARBIDE in tank car or tank truck quantities, in compartment tank cars or trucks with other CARBIDE chemicals, or in 55-gal. drums (LCL or carload lots). Samples are also available. For detailed information, call the Technical Representative in your nearest CARBIDE office.

A Technical Information Bulletin on 2-methyl pentaldehyde can be obtained by checking the coupon.

Sure cure for epoxy resins

CARBIDE's alkylene amines are effective curing agents or hardeners for both liquid and solid types of epoxy resins. Diethylene triamine, triethylene tetramine, and dimethylamino propylamine are excellent for room-temperature curing of small masses of resin. These amines are especially suitable when used with resins intended for potting or encapsulating electrical components. The alkylene amines are also used as curing agents in laminating resins.

An interesting new booklet on CARBIDE's alkylene amines is now available. For your copy, check the coupon.

Butanol in surface coatings

Butanol (n-butyl alcohol) is one of the true "work horses" of the paint and surface coating industry. It is widely used as a solvent for urea-formaldehyde and urea-melamine resins in various coating formulations. It is both a solvent and a viscosity reducing agent in alkyd surface coatings. Mixtures of butanol and butyl CELLOSOLVE are added to oleoresinous and spirit varnishes to improve flowout and brush-ability.

For technical information on this useful alcohol, check the coupon.

Improving metal-drawing compounds

Tallow-based compounds are traditional as lubricants in metal drawing. However, they can be greatly improved with little change in formulation – by using CARBIDE's ethanolamines as the emulsifying agent.

Triethanolamine soaps in combination with tallow can be used to control viscosity and reduce friction between die and work-piece at a suitable drawing temperature. The lubricant emulsion helps to prevent galling or welding between workpiece and die surfaces. Additionally, the ethanolamine soap enhances the removal of the tallow lubricant from the work by simply flushing with warm water. CARBIDE's triethanolamine gives excellent stability to the compound while being used, and also in storage.

For pre-dip, swab, and spray-type applications, drawing compounds emulsified with triethanolamine soaps are used on sheets, strips, and blanks prior to pressing, drawing, forming, or stamping operations.

Information on CARBIDE's ethanolamines in metal-drawing compounds can be obtained from a CARBIDE Technical Representative. General information, properties, applications, and handling and storage methods are contained in a new booklet, "Alkanolamines and Derivatives." Please check the coupon for your copy.

Tear out this coupon. Check the boxes on which you'd like more information, and mail to Dept. H, Union Carbide Chemicals Company, 30 East 42nd Street, New York 17, N. Y.

☐ 2-Methyl pentaldehyde.
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And remember, there is a CARBIDE sales office near you where you can obtain the services of a CARBIDE Technical Representative. His wide industry experience is backed both by extensive chemical training and by Technical Specialists.

"Cellosolve" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

UNION CARBIDE CHEMICALS COMPANY
DIVISION OF
UNION CARBIDE CORPORATION

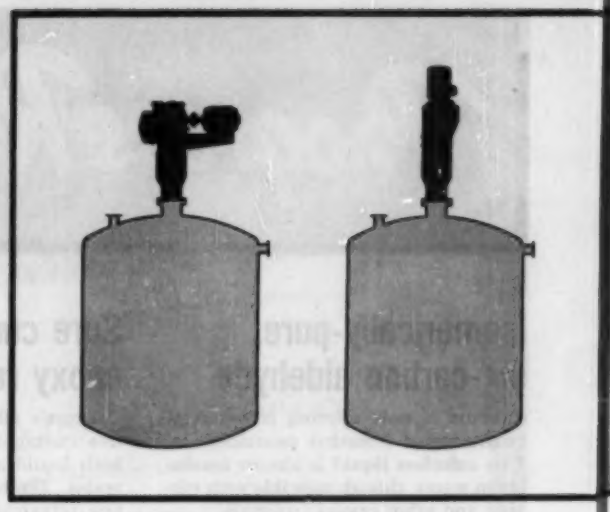
For more information, turn to Data Service card, circle No. 72

Q. If headroom is no problem, do vertical motor mixer drives have any advantages over horizontal motor units?

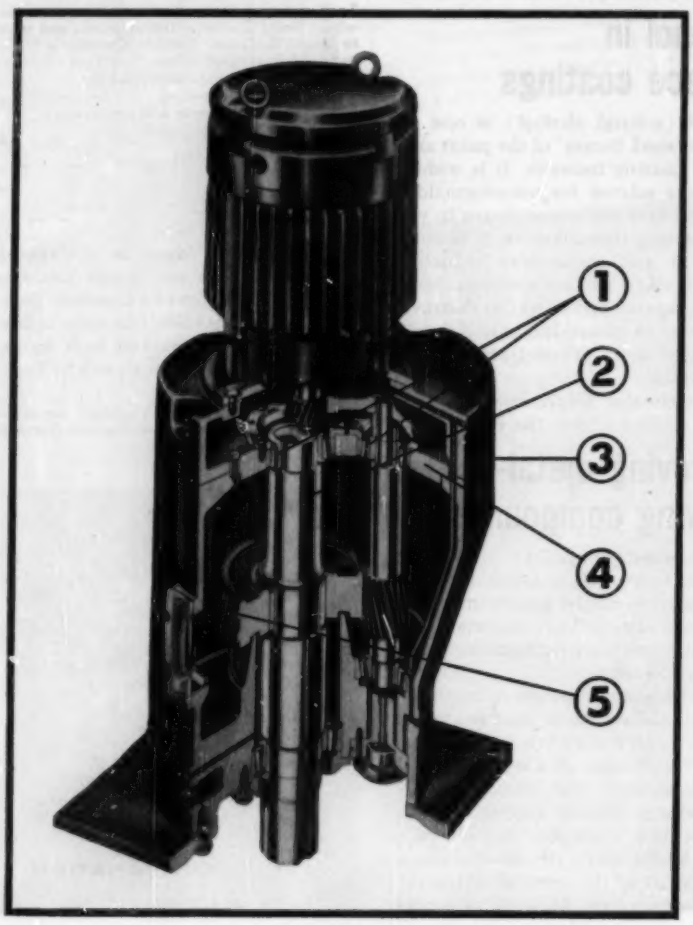
A. Philadelphia horizontal motor "3800 Series" and vertical motor "MV Series" both have the same high quality construction. From the standpoint of performance, drive efficiency and life expectancy, they are equal. However, each type has certain inherent advantages.

"3800 Series" units have an advantage in operating and mounting flexibility to meet changing process requirements. Change-gear sets are easier to install. Motors are somewhat easier to replace and horizontal drives can more readily utilize special motors such as variable speed types. Headroom requirements for the "3800 Series" are minimum for maximum bearing span. On the other hand, horizontal motor drives occupy more room immediately above the tank top and stresses imposed upon mounting nozzles by the overhung motors can require extra drive support . . . especially in the larger sizes.

"MV Series" vertical motor units have an advantage in that they occupy much less space at tank top, making it easier to install process piping. Better access to the tank is provided. Supporting difficulties are minimized because vertical drives are better balanced. While vertical motor drives are less flexible for a quick change of motors and output shaft speed, their greater inherent design simplicity makes them a more economical offering. They will usually be a sound choice when adequate headroom is available.



it's questions like these . . . that get

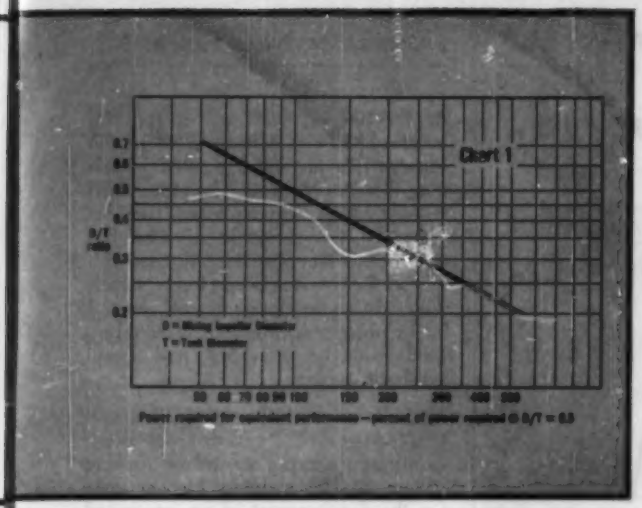


Q. What design factors insure maintenance of drive shaft alignment, even after years of operation?

A. The ability of a shaft to run dead-true, through years of operation, depends primarily upon the design approach of the manufacturer. When extra large, extra high capacity bearings (1) are used, shafts (2) can be larger, stiffer, heavier duty. When other drive components . . . housings (3) bearing supports (4) and gearing (5) . . . are designed for extra strength, shafts will be supported with near-absolute rigidity. Result: damaging shaft deflection simply cannot occur. Gearing is effectively isolated from unbalanced loads.

You will get truer shaft operation at shaft seals.

Whenever alternate offerings are being evaluated . . . and if price and output torque ratings are competitive . . . then the basic design approach of each manufacturer demands careful examination if you are to get full advantage of the savings that result from better performance, less maintenance and longer life.



Q. Are "dollars per horsepower" a valid basis for comparing mixer values?

A. No. Mixers having the same horsepower rating and drive efficiency can vary widely in torque rating. Torque applied to the mix is what does the work and torque is what you pay for. When comparing mixer values, the most important first step is that of developing torque ratings of alternate units offered. Using the most familiar units, torque can be calculated as follows:

$$\text{Torque (lb. inches)} = \frac{63025 \times \text{Motor HP}}{\text{Mixer shaft RPM}}$$

The mixer having the lower torque rating must use a higher mixer shaft speed and smaller diameter impeller to maintain a given level of mixer output. This can lead to unsatisfactory performance. However, a mixer of equivalent horsepower rating but with a higher torque rating and larger impeller will do the job well. For an idea of the importance of impeller size, the chart shows the influence of impeller diameter in relation to tank diameter (D/T ratio) upon motor HP required for a specific level of performance in many industrial mixing operations. The bigger impeller at the slower speed (higher applied torque) will be a sounder choice.

down to basics in buying mixers . . .

YOU GET MORE FOR YOUR FLUID MIXER DOLLAR

because we design and build the *whole* unit

It's simple economics! Philadelphia Mixer is the only manufacturer that designs and builds the complete unit. Because we control production and costs, we can afford to give you more mixer per dollar. For example:

- Extra large, heavy duty bearings throughout.
- Extremely heavy output shafting—machined, ground and polished.
- Drives designed with extra strength and rigidity to take maximum thrust and unbalanced loads.

You don't pay a premium for these extras—or for the better performance and longer life of a Philadelphia. You get them as a bonus.

You can select your Philadelphia Mixer from six standard models. 1 to 200 HP. Special units to 500 HP. Horizontal or vertical drive. Mechanical seal or packed stuffing box. Paddle or turbine type impellers.

Get the full story on Philadelphia Mixers. Write for Catalog A-27. It contains complete mechanical design information that permits you to make a catalog selection of the mixer that best suits your requirements.

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Industrial television (closed circuit TV), the newest means of visual communication, is now increasing profits and efficiency for industry, science and education. Undoubtedly, there is some area of your present operation (continuous process control, quality control inspection, data transmission, plant or property protection, monitoring gauge and instruments, safety, dispatching, etc.) that can be improved by the use of industrial TV. The question is—what area?... How will it be benefited?... and what is the cost?

Blonder-Tongue and its nationwide staff of specialists eliminate all the guess-work in industrial television by offering you a free survey in your plant, office, etc. to demonstrate where and how industrial television will benefit you, what an installation involves and the cost. With industrial TV increasing efficiency at companies and institutions similar to your own, you can't afford to miss this opportunity to find out at no risk, no obligation what industrial TV can do for you.

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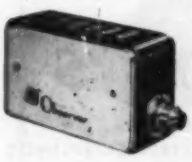

A completely automatic Blonder-Tongue industrial TV system (compact, rugged camera; automatic light compensator; TV monitor) providing quality pictures can be installed for less than $2,500.00.

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about our authors

E. D. Reeves, who writes for this month's CEP on *Management of the Future,* has just been elected executive vice-president of Esso Standard Oil Co., after serving since 1949 as executive vice-president of Esso Research and Engineering. At Esso Research, Reeves has been closely associated with development of several major process achievements, including fluid catalytic cracking and butyl synthetic rubber.

N. J. Ream *(An Integrated Approach to Management Problems)* has been, in his own words, "one of the leading proponents for the last twelve years for the development of an integrated approach to problems of management, and while with I.B.M. developed a model integrated system for the textile industry." Ream is presently director of systems planning for Lockheed Aircraft Corp.

Authors: Ream, Wall, Taube.

Eugene Wall *(Information Systems)* has been with Du Pont since 1943, is now consultant in the company's Engineering Department, operations research group. He is the author of many articles in the field of information storage and retrieval.

Mortimer Taube considers that his most important engineering contribution has been the development and publication of a scientific theory of information storage and retrieval. He writes for CEP this month on *Storage and Retrieval of Information.*

Authors: Schutt, Goode, Fowler.

H. C. Schutt *(Light Hydrocarbon Pyrolysis)* thinks that his most specific contribution to the art of modern process plant design has been a rational approach to the design of high-temperature gas phase reactors.

about our authors

H. H. Goode, technical director of the Systems Division at Bendix Aviation, brings to CEP readers the experience of many years in systems engineering and management over a broad area of industry. His subject—*Systems Engineering and Management.*

A. H. Fowler, who with **G. R. Jasny,** authored this month's article on *Application of Air-Lift Pumps to Multi-column Plants,* has specialized in the development of automatic controls and special equipment for uranium processing.

C. A. Thomas, President of Monsanto Chemical Company, who gives his view of the future in the chemical industry, has singled out pioneering as his major field ever since his early days in the industry. In the General Motors Research Labs he met C. A. Hochwalt and out of this came the Thomas-Hochwalt Laboratory for Industrial Research in 1926. In 1936 the laboratory, and Thomas, became part of Monsanto. Since then Thomas has been in the forefront of developing new products and markets for the company.

Developmental production of Nylon film has started at Foster Grant's Manchester, N.H., plant. It is available in thicknesses from 1.5 mils to 20 mils, and in widths up to 36 in.

An alkylation plant and an isomerization plant will be built by Fluor for Standard Oil of California, Western Operations, at its Richmond, Calif., refinery. The two new plants will be integrated with the 55,000 bbl./day fluid catalytic cracking plant under construction by Fluor at the same site.

Preliminary design and analysis of heat exchangers and steam generators for liquid sodium-cooled nuclear power systems will be carried out for the AEC by three firms: Griscom-Russell, Massillon, Ohio; Alco Products, Schenectady, N.Y.; and Combustion Engineering, New York City. Purpose of program is to develop less expensive and more reliable major non-nuclear components which can withstand exposure to liquid sodium coolants and which can operate at the high temperatures and pressures demanded by modern electrical generating stations. Work under the AEC contract is expected to be completed in about eight months.

TAKE THE "SHOCK" AND SURGE OUT OF QUICK GO LIQUID LINES

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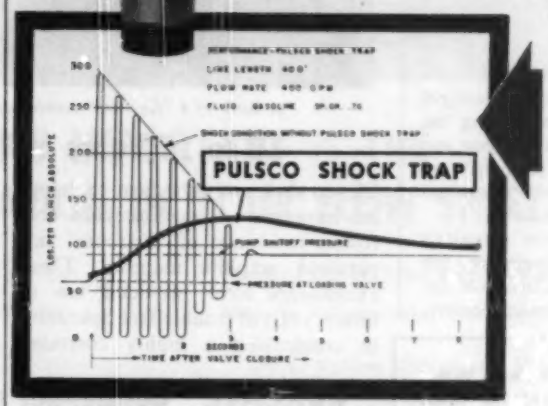
BELLOWS SHOCK TRAP

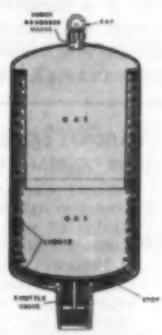
Here's the finest protection against shock and surge. Take the "hammer" out of high velocity liquid lines – remove the danger of broken lines, meters, and overstressed loading equipment. Assure correct meter readings consistently with the Pulsco scientifically designed Bellows Shock Trap

HERE'S PROOF

Check this performance chart for actual field results. Compare the Pulsco trap with its easy action to the "shockingly" damaging condition set up in the same line when Pulsco was not used.



Simply install the Pulsco Shock Trap if you are interested in getting rid of a bad "hammer" condition in your existing lines or in preventing this serious condition if you are laying out a new installation. Our engineers will gladly consult with you without the slightest obligation. Simply write or telephone.



Sectional view showing how the gas-filled Bellows absorbs shock and how the Shuttle Valve dampens rebound.

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News from
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Marketing Manager, Chemical Products

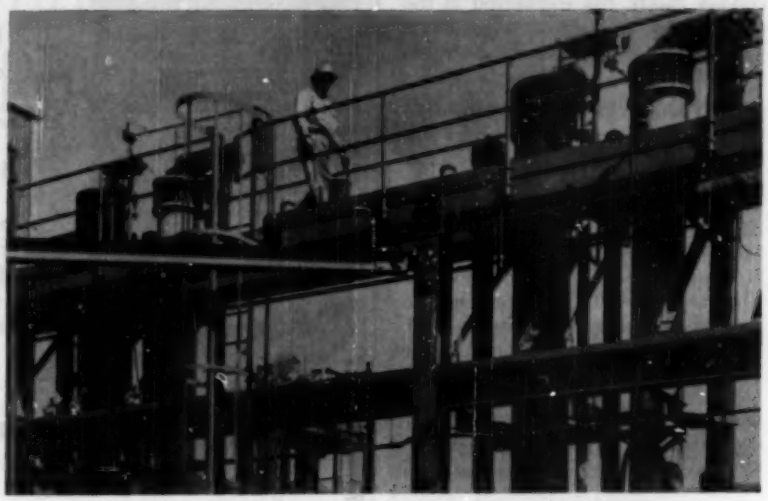
W. W. PALMQUIST

Mr. Palmquist was graduated from Yale University with a B.S. in Chemical Engineering. He has spent ten years preparing design proposals, developing new designs and improving existing designs of "Karbate" chemical processing equipment. Based on this extensive design and development background, Bill was made Manager of Sales Promotion and Development for the Chemical Products Sales Department.

For the past year, Bill has been Chemical Products Marketing Manager and is responsible for marketing the complete line of "National" carbon and graphite products and "Karbate" impervious graphite for the chemical processing and allied industries.

He is a member of the American Institute of Chemical Engineers, the National Association of Corrosion Engineers and the Electrochemical Society.

"KARBATE" CONDENSERS PROVIDE LONG, ECONOMIC LIFE IN CORROSIVE SERVICES



A bank of 4 "Karbate" condensers in an organic chemical plant.

10 to 15 Years of Trouble-Free Service

Eleven shell and tube heat exchangers have proved the excellent corrosion resistance of "Karbate" impervious graphite material. These exchangers have provided ten to fifteen years of trouble-free operation in condensing a highly corrosive *chlorinated hydrocarbon.*

Based on this performance record, additional "Karbate" shell and tube heat exchangers are planned for expansion and renovation programs in this plant.

"KARBATE" Condenser replaces Silver Condenser

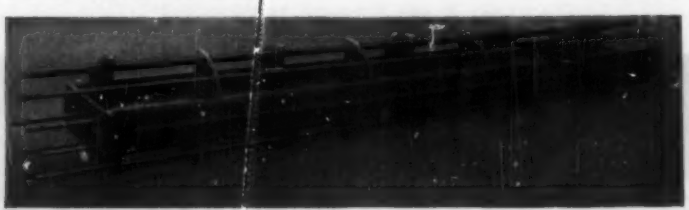
To overcome the silver condenser problems of high-cost, specialized fabrication and exacting maintenance procedures, a "Karbate" shell and tube condenser was installed by a major chemical company in an *acetic anhydride* condensing application.

The unit is handling 80% *acetic anhydride* vapor at a temperature of 100°C.

The replacement "Karbate" impervious graphite unit has provided excellent heat transfer and examination after 20 months of service show it to be as good as new.

NATIONAL CARBON FABRICATES 20-FT. LONG "KARBATE" TUBE HEAT EXCHANGER

National Carbon Company was requested to replace a steel bundle in an existing all steel shell and tube heat exchanger. This presented a problem of 20-foot long tubes plus a two pass shell side arrangement. Photograph below illustrates the design of the "Karbate" baffle system used to reproduce the two pass shell feature. The 20 foot "Karbate" tube bundle was installed in the customer's existing steel shell and is now in service.



NATIONAL TRADE-MARK

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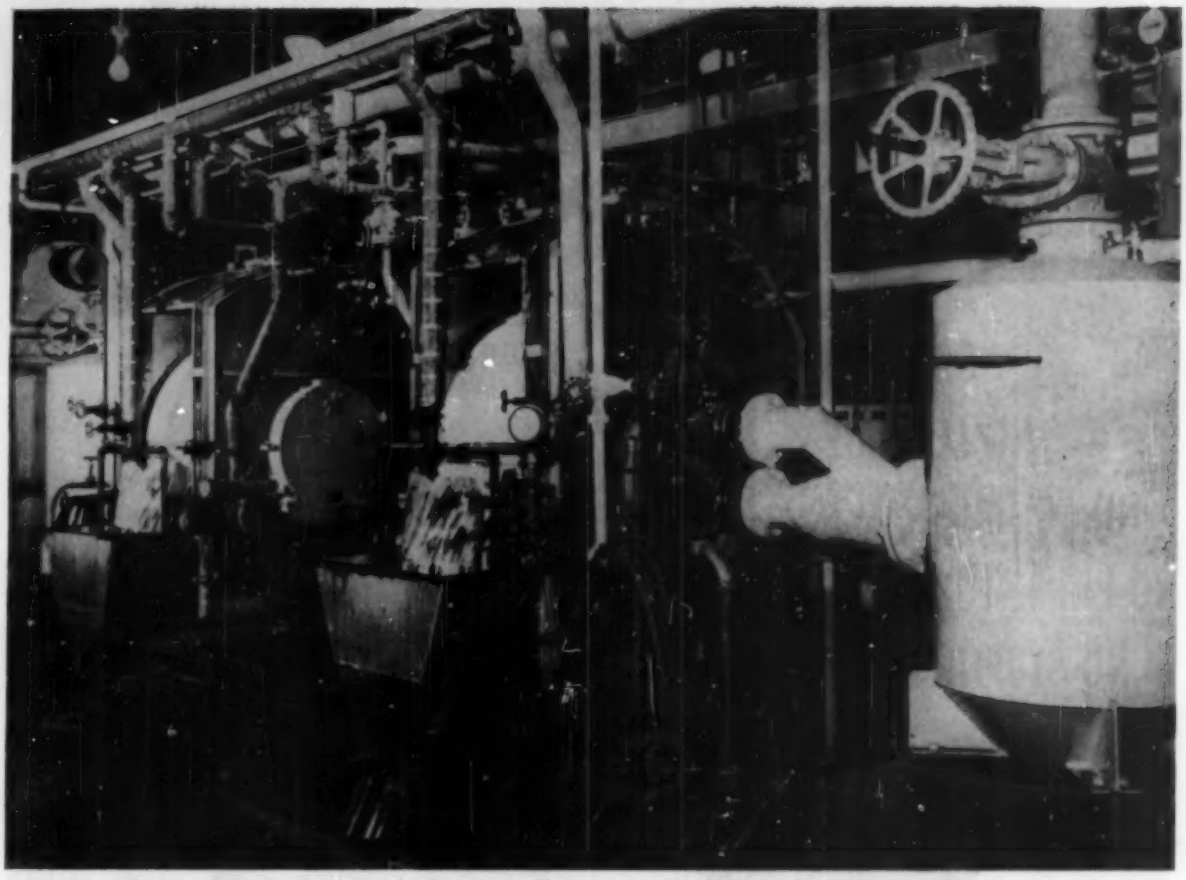
UNION CARBIDE



HOW IMPORTANT IS THE FILTER STATION IN YOUR FLOW SHEET?

If the filtration needs in your plant can be met by any filter of a given size, then you may want to buy with price as the only consideration.

But, if you want a filter designed to give the highest efficiency in meeting the requirements of your flow sheet, then Eimco's long experience and facilities will give you the plus value when your filter needs are studied and researched from the standpoint of such typical featurer as the hydraulics of liquid flow, pressure drops, washing and drying efficiency, capacity sizing, filter media selection and many other features which make filter selection a science.

This picture shows an Eimco Engineered filter station in a highly successful chemical plant. It is the result of customer engineering and Eimco engineering cooperation based on all of the features listed above.

Let Eimco help you with your liquid-solids separation problems through filtration, sedimentation or clarification.

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B-374

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Replace with PULSAFEEDER for Trouble-Free Liquid Metering

NO LEAKAGE
NO CONTAMINATION
NO PRIME LOSS
NO STUFFING BOX

When the time comes to replace the chemical pump in your process, replace with a PULSAFEEDER—the *leak-proof* chemical pump that has *no stuffing box* or other leak-likely seal.

Lapp Pulsafeeder is a combination piston-diaphragm pump . . . positive displacement is achieved by a reciprocating piston pumping a hydraulic oil against a diaphragm. This hydraulically balanced diaphragm isolates the liquid being pumped from the pump's working parts—eliminates need of stuffing box or running seal—prevents product leakage and contamination. Pumping speed is constant, variable flow results from variation in piston-stroke length . . . controlled manually by hand-wheel, or, in Auto-Pneumatic models, by instrument air pressure responding to any instrument-measurable process variable.

WRITE FOR BULLETIN 640 *with typical applications, flow charts, description and specification of models of various capacities and constructions. Inquiry Data Sheet included from which we can make specific engineering recommendation for your processing requirement. Write Lapp Insulator Co., Inc., Process Equipment Division, 3706 Poplar Street, Le Roy, N. Y.*

Lapp PULSAFEEDER
CONTROLLED-VOLUME CHEMICAL PUMP

For more information, turn to Data Service card, circle No. 40

CEP.....trends

Chemical earnings per share to rise

The year closed with increasing indications of satisfactory business and continued inprovement in 1959. The stock market continued strong at the year end at around the highest levels. It is difficult to see at the moment why many of the drug and chemical shares, some of which have scored advances of 20 to 30 points or more since last fall, should move immediately higher. They are already discounting optimistic estimates of 1959 earnings. On the other hand, there seems to be no reason to look for a substantial decline. The pressure of the big money looking for investment continues and this sort of support can be expected on any substantial sell-off in stocks. Later in the year, when more tangible evidence of business improvement is seen, the market could move ahead further.

Wall Street analysts believe that chemical companies are now entering a period of several years when they will be able to show steady gains in reported earnings per share year by year. In the past decade many firms in this group, although considered "growth companies," have shown only modest gains in earnings per share. This has been because depreciation and amortization charges on heavy expenditures for new plants have been increasing, thus holding back profits. Now most of the big firms do not expect to increase these annual charges, so that when new capacity is utilized it will show up in gains in reported earnings. As this trend becomes established it probably will be reflected in the stock market.

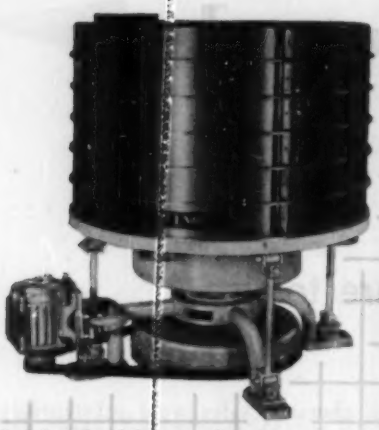
A milestone in financial circles was the announcement of a three for one split of the shares of American Telephone, and an increase in the $9 dividend rate which has been unchanged for 37 years. This may be considered a sign of the times and evidence of the shrinking value of the dollar. The phone company perhaps wanted to help its stockholders offset the higher cost of living. It also, no doubt, has an eye on the money market, rising interest rates, and lower bond prices. To compete for investor's capital to continue its annual expenditures on plant of $2 billion, the company decided to be more generous with dividend payments. The money market, that is, the rate of interest this year, will depend to some extent on how business goes in 1959.

Last year, the Manufacturing Chemists Association reports, chemical sales were substantially the same as the all-time high reached in 1957, although they started off badly. But they gained momentum in the latter part of the year, especially in the final quarter. Earnings for the year, of course, were lower. A continuation of current sales rates should bring record sales and new peak earnings in 1959 for many companies. The average of chemical prices stands about the same as it was a year ago although there have been some reductions in key chemicals.

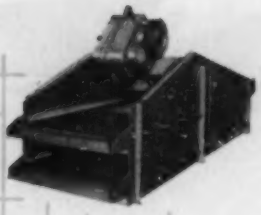
The threat of long-range inflation continues even though the government is talking of efforts to balance the budget. Canada also is worrying about inflation and has done some recent financing at 4%, but, like American bonds, these bonds have sold off though not as drastically as American issues. The real cause of inflation, in spite of the fact that legislators in Washington prefer not to know it, is, of course, the steady rise in wages. There is no sign that this will be restrained in the foreseeable future. Meanwhile, it is interesting to note that wholesale commodity and retail price indexes are up less than 10 percent since 1955. Prices of raw materials are actually down and closed the year at the lowest level since before the Korean war. This is fairly good evidence that we are really having labor wage inflation more than money inflation.

On the foreign front there is a considerable amount of news—some good, some bad. In South America, Venezuela has just raised the tax on oil company profits to 60% from 50%. Meanwhile an astute reporter recently returned from a tour of South America believes that the next spot which will develop economic complications might be Peru, which would not be good for local producers.

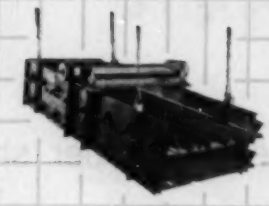
In Europe a momentous move has been made by ten Western Nations to make their currency more freely convertible into the dollar and other currencies. At the same time France devalued the franc by 17½%. Regardless of the long-range effects of this, it is a sign of steadily strengthening European economy, and may indicate a trend to the old "normal" days when currencies could be freely exchanged in international trade. One result may well be to create more foreign competition for American business, especially in drugs and chemicals.



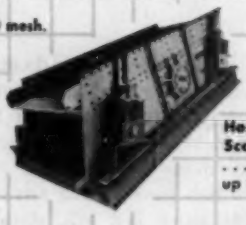
Stainless Steel Gyratory Screen
. . . for size classifications 2 to 325 mesh.



Horizontal Screens
. . . for separations up to 2½ inches.



Small Inclined Screens
. . . for separations 1½ inches to 40 mesh.



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up to 12 inches.

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. . . From smallest to largest

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- And you can get your screen complete with motor, drive and control — all from one manufacturer!

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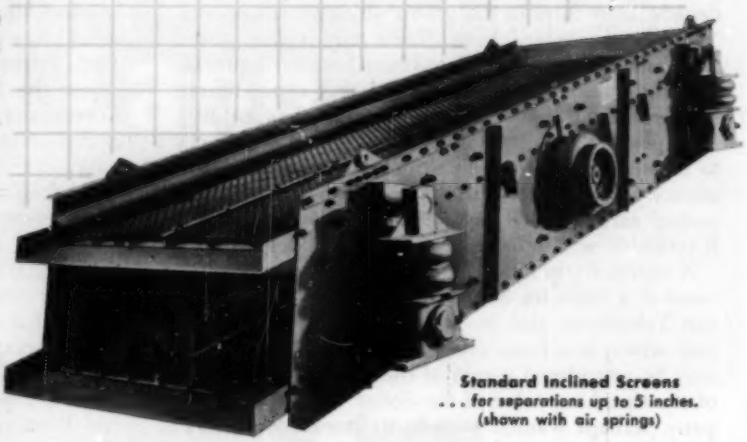

Standard Inclined Screens
. . . for separations up to 5 inches.
(shown with air springs)

ALLIS-CHALMERS

A-5583

For more information, turn to Data Service card, circle No. 1

opinion and comment

Unforgettable comments of 1958

As the Editor Sees It—Gleanings from the old year:

Man and the Computer. How does the man with engineering experience react when one of the shiny new machines is installed in a nearby office and he tries concocting his first few tasty morsels with which to assuage the voracious appetite of the thing? A veteran of several hundred such computer adventures says, "The trouble is, a man, no matter how expert in engineering practice, is usually trained (for very good reasons) to find the simplest possible means of expressing his problems for conventional solution. Computers don't work this way, at least [not] economically." What our expert advises is, "look upon your old problem-simplifications as oversimplifications. Prepare yourself to take the most elementary and make something really complex out of it." The chemical engineer who will lead the procession, according to our expert, is the one who will learn to use fundamental physical and mathematical principles to describe his engineering problems to a computer, and in so doing, will become skilled in formulating problems larger than the ones he can solve himself.

War and the curriculum. Does the pressure of wartime expediency tend to bring about major changes in engineering curriculum? This question was recently explored by a small group at the Cincinnati Annual Meeting. Consensus was "no," in so far as chemical engineering was concerned. It was "yes" in the electrical and electronics fields, however, in World War II. This was brought about by the development of radically new control systems concepts, and such devices as the servo-mechanism. Widespread applications of these to weapons technology required new training, etc. Chemical engineering training met the needs, and, presumably, would again without major changes. It is the "cold" war, or international economic development competition, that is creating pressures for Ch.E. curriculum changes in the direction of more scientific planning of the process—all of which is expected to lay the groundwork for improved manufacturing economics. Under discussion from time to time, has been the question of whether an individual might expect to acquire advanced training in mathematical techniques, process dynamics, etc., through a carefully laid out reading program, or by attending an occasional one-day orientation lecture. Results of such discussions have been inconclusive; too many feel that the adage, "quickly learned, easily forgotten," would apply. The longer range work being done by a number of companies, and some A.I.Ch.E. local sections, is noteworthy in its success. The question really is, can larger numbers of individuals be reached and materially aided? More discussion during 1959 is looked forward to.

Recession and the builders. A good deal is being said about the business recovery, and the satisfactory earnings levels reached by the chemical industry. Engineering construction and equipment manufacturing people are still talking of "slowness" in their operations, which is related to the reduced rate of plant expansion that is still with us. From talks with certain people at the Cincinnati Annual Meeting, it is possible to believe that a major acceleration in the rate of process-unit building is under way, tied in with the growing attention being shown pollutants. "In-plant pollution control," a field in which chemical engineers are playing a major role, is believed by us to be such an important subject that CEP is, beginning in March, launching a series of informative articles which will not only reveal what others are doing, but will also provide "do-it-yourself" details.

As to keeping our engineering-constructors in "high gear," a number of comments have been heard to the effect that we, as a nation, might better spend some of our foreign aid funds in projects which would improve productive capabilities of friendly countries, making sure that our own firms export the know-how. The recent Euratom agreement specifically provides for such participation by American firms, according to our advisers. Why not extend this principle to chemical processing areas?

Human relations. This seems a most appropriate topic with which to close this commentary. The subject came up recently with an historically-oriented friend of ours who has for the past several years been studying occupational trends of engineers. The engineer, says this friend, should realize how comparatively well organized and smoothly operating his technical-problem solving techniques are. In contrast to this, the social scientist has a really difficult situation; people are today, for example, still arguing about human relations problems that were being widely debated 2,000 years ago. Our friend's point is that the engineer would do well to realize that today, more than ever, he is becoming involved in human relations—in his company management responsibilities, in the unification of his profession, and so on. Also, that there are a number of aids available to help one understand and solve problems in human relations when they arise. Sounds as if the problem-solving approach of the social scientist hasn't been completely unsuccessful! J. B. M.

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Charles Allen Thomas, *President,*
Monsanto Chemical Co., St. Louis, Mo.

In his analysis of the needs of the chemical industry, Thomas gives a New Year challenge. The special feature section following—Technology of Management—and other 1959 features, will explore in detail advanced techniques for achieving the goal set by Thomas.—*The Editors*

WHAT ABOUT the future? The chemical industry in the next decade will be characterized by the greatest competition our industry has ever known. There will be an increasing demand for chemicals and plastics, but *satisfactory profits* will be had only by the low-cost producer. It will be quite different from conditions in the past ten years when there was a wild rush to build new plants or enlarge the present ones to meet the increasing demand of goods, sometimes with not enough regard to costs. What did it matter if your process yielded a product at a somewhat higher cost than it should—there was margin enough, and the more important thing was time. Many plants that were built during World War II, or at the time of the Korean War, carried 100% or partial Certificates of Necessity and this also accented the urge to get onstream and start the payout. Also since World War II the ready availability of know-how and turn-key plants and processes at a price much less than that represented by the cost of ingenious engineering and development has been a major factor in the decision of companies not in the chemical business, but with excess cash or credit, to enter it. We have seen, too, our traditional suppliers of raw materials and our old intermediate-products customers enter the manufacturing field in competition with us. Often, in order to have a larger divisor for a lower unit cost, these plants were built for so-called optimum capacity and, as this is generally greater than the immediate needs of the builder, the excess production was offered on the open market. Today, consequently, the industry's capacity to produce a great many of its major products is greater than the ability of its customers to consume them.

To further aggravate the situation, we also face more and more competition from overseas. Many of the European chemical plants were bombed out during the war. While they were rebuilding, we were busy with reparations and occupation commission, much of our production was lost in foreign markets.

". . . automation must enable us to make major advances in design or operation which will reduce capital costs as well as operating costs."

creased our desire to produce more. Now, however, these plants have been rebuilt, based on newer and more economical processes (largely with money from our Government), and these goods are exported to the United States at prices under ours. Labor rates in the chemical industry in Western Europe and the Far East are about one-fourth of ours. Our costs of building plants and laboratories are considerably higher. Thus their amortization costs are lower. In view of the above, it is understandable that on some products they can profitably sell at prices lower than ours. This is particularly true of many synthetic organic chemicals which are made in small volumes carrying a relatively high proportion of man-hours for manufacture.

And we hear from Nikita Khrushchev, speaking to an American editor, that Russia is declaring war upon the United States in the peaceful field of trade. Khrushchev forecasts the investment of 25 billion dollars in the chemical industry in Russia's next seven-year plan. We must assume that a large portion of its products will be exported to this country. Hence, we have another dangerous competitor.

The United States chemical industry needs new products and less costly ways of making the old ones. If my guess is correct, the chemical engineer in the near future will make obsolete some processes now in existence. Some plants built in the heyday of the last few years will have to be redesigned or go out of business. Tomorrow's plants will have more pieces of equipment designed by clever engineers to do a specific job well under a particular set of conditions, rather than using the so-called standard design units. Chemical firms which continue to show a profit on their operations will do so largely because of the brains of their engineers to give them the lowest costs. Economic survival will depend more and more on ingenious engineering.

The engineer's tasks will not be easy. The rising costs of materials of construction and the rising cost of labor will be other difficulties to overcome. We all know how the cost of construction has risen in the last decade and we see no leveling off ahead—but just the reverse. With prices being held down by competition and overinstalled capacity, the ratio of dollar sales to dollars invested is becoming smaller and smaller. To get the most production per dollar of machinery and equipment is the answer to excessive amortization costs. Here, again, we must turn to the engineer.

For many years we have been making good use of the concepts of unit operations in solving design problems. These concepts are valuable, but to design tomorrow's plants we must have an even better understanding of the mechanism of the reactions we engineer. It is alarming, but on second thought stimulating, to realize that the design of many of our present operating plants was based on inadequate knowledge. Today when the engineer tackles the job of designing an automated plant, the inadequacy of this knowledge stands out in bold relief. One of the pluses in the trend toward automation is that it has forced us to return to the laboratory to fill in the voids of our basic understanding of the reactions with which we are dealing.

Today our fundamental knowledge of mass transfer, reaction kinetics, fluid dynamics and heat transfer is being broadened considerably, and our ability to utilize this knowledge is greatly facilitated by the use of computers.

We are all enthusiastic about the possibilities of applying systems engineering and computer controls. Management is aware of its potentialities in bringing about savings in capital and operating costs and, consequently, many of our companies have authorized extensive programs of research and study to establish their real utility.

As we know, the objective of systems engineering and automatic control is not only labor saving. In some processes utilizing expensive raw materials, costs are influenced more by improvement of yield than reduction in labor. Likewise there are processes where capital charges far exceed labor charges. Therefore, to be really fruitful, automation must enable us to make major advances in design or operation which will reduce capital costs as well as operating costs.

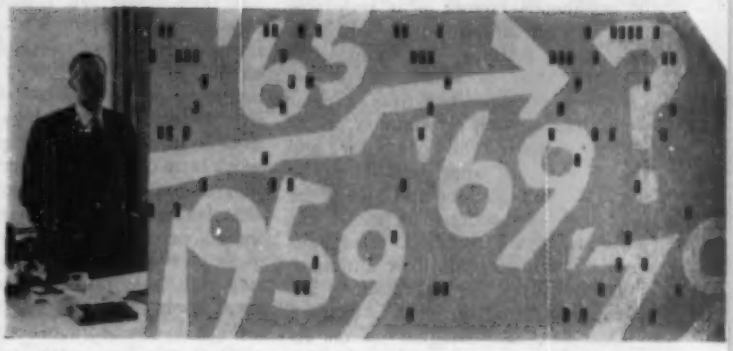
The intelligent and successful application of systems engineering and automation requires men of special training. Recognizing this, our company has been operating an extensive program for training chemical engineers in these specialized fields. In addition to skill, the use of these new methods will still require sound judgment. We must remember that the method or the tool is never an end in itself, but is only a means of solving the problem at hand. We must not fall into the error of discarding the old for the new just because of novelty. Economy in costs and reliability of performance must remain the engineers' primary standards.

From the Award Banquet Address "Engineering and the Chemical Industry—A Prognosis" at A.I.Ch.E. Annual Meeting, Cincinnati, Ohio.

technology of MANAGEMENT

Management of the Future

Will the management executive be obsolete in the automated future of technically based companies? Many seem to think this could happen. Esso's Executive V-P says no. In fact, there will be a greater and greater need for management. Reason—The vital role of human imagination.



E. D. Reeves
Esso Standard Oil Company, New York

Today a basic question faces us. This question is: in view of all of the technological developments that will be made, in what position will the management of technically based enterprises find itself? Will such management have anything left to do, or will it be just another victim of technological unemployment?

This question is not as outlandish as it sounds because I have talked to quite a few technical people who have been worrying about this question. Although it is true that much of their concern arises from their not having full appreciation of just what management does, I do think that their concern is nevertheless understandable.

It has been assumed by those who are worrying that the major responsibility of management is to gather facts, draw logical conclusions from these facts, and then initiate action of some sort dictated by the conclusions. This is something that any good computer could do, once we equip it with the right memory, an appropriate program, and a suitable feedback system. Based on the assumptions used, you can see that most of our management people would soon be out of work.

This is quite an interesting idea, but I think we should take another look at it to see if it is true. To do this, we will have to think a little bit about what is going on and try to take a look at the future from the standpoint of what lies ahead of us technologically and what this is going to mean in terms of people.

Technologically, at least, it seems to me that our future is fairly clear. There is unquestionably a lot of progress ahead of us. Furthermore, the forward surge of technology is gaining momentum, and we can expect an ever-increasing tempo of new technology.

If we try to predict the future in terms of what has happened in the past, we can certainly expect tremendous benefits as our new technology continues to develop. In the past, technology has created for us a whole host of new tools, processes and products which have combined to provide Americans with an almost startling increase in our standard of living in just the last hundred years or so. While it is a little difficult to estimate according to a numerical index the magnitude of this increase, a good case can be made for the assumption that we have increased our standard of living some two-hundred-fold through a combination of mechanical energy, more efficient tools, new products, and new ways of doing things plus the release of a great many people from nonproductive activities to productive ones. Furthermore, this has all been accomplished under a system in which the operation of individual machines, except for the use of limit controls of various types, required the supervision of a human operator who provided the real control.

Now, all of this relating to human operation and supervision is going to change, and while we can expect continued progress along what might be termed conventional lines, that is, more new tools, processes and prod-

continued on next page

Future management

continued

ucts such as we have been getting in the past, something new is about to be added: Feedback control using memory-equipped computer systems. This will involve circuits consisting of sensing, input feed, gaming, output, feedback, and control steps. The gaming feature will be supplied by a memory system built into the computer so that it can consider all sorts of extraneous factors as it translates input signals into output signals. One can easily imagine, for example, a machine shop in which all of the machines are operated from a computer tied in with information on inventory levels. The computer will then decide just what parts should be made in each machine and give it the necessary instructions to make the particular parts required. The individual machines will then automatically shift from one operation to another, depending on what is needed.

One can also imagine an oil refinery of the future with a built-in memory which will permit it to anticipate changes in demand depending on the time of the year, weather forecasts, market conditions, etc., and then adjust itself to make whatever products it calculates will be required. As your imagination allows you to look in on these factories of the future, most of the people associated with such operations in the past, including the managers, will seem to have disappeared and you cannot help but wonder what has happened to them.

Sometimes when one discusses the relationship between people and technology, it helps to look backward to establish perspective. At one time, not too many years ago, about sixty percent of the working population in this country consisted of farmers and our nation's struggle for a bare existence was indeed a real one, in spite of all the people engaged in growing food. Today, farmers comprise less than ten percent of our work force and we have more food than we know what to do with. It is interesting to take a look at what has happened to fifty percent of our work force after it was displaced by technology. These people are obviously not sitting around wondering what to do now that they are no longer needed on the farm, but we find them all over the country busily making things such as automobiles, refrigerators, television sets, etc., that they could not have made while they were needed for farming.

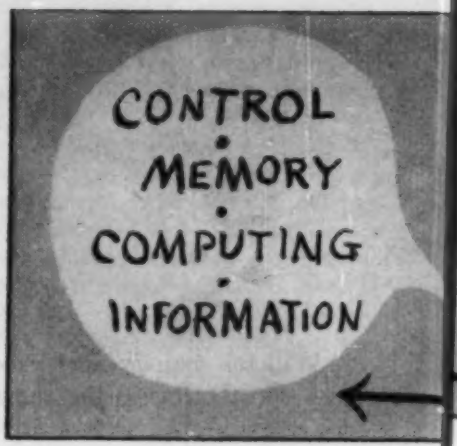
Then, one can look in another direction and see one man with a power shovel doing the work that used to require one hundred people not so long ago with hand shovels. What do you suppose has happened to the other ninety-nine? Keep looking and you will find that they are operating ninety-nine other power shovels or similar equipment. The same one hundred people are hard at work but doing one hundred times as much work as they did before.

As we continue to think about what has been going on, I think we can learn some interesting lessons concerning the results of technology as it affects people. The first is that there are more people working today than ever before, so technology obviously does not either put people out of work or make it unnecessary for them to continue to work. The second is that technology—as it increases individual productivity—requires greater skills on the part of those who use our more efficient but more complex technical tools. The net result of technological developments, then, is to shift people from unskilled to skilled jobs and more and more into management-type activities. While a farmer and a scythe have always typified unskilled labor, today's farmer driving a reaper is essentially a manager in his own right.

As you can see, I have been trying to slowly develop the role of the manager himself in tomorrow's technology. I think you can visualize this most clearly by considering just what it is we are trying to do, because we are not trying merely to replace the human race with a race of mechanical monsters. Certainly, if our objective were only to create a Frankenstein monster who could destroy us, we should stop right now and turn our attention to less suicidal pursuits.

The real objective of technology, as I see it, is to extend the capacity of individuals to produce, to understand the world they live in, and to secure control over their environment. In other words, what we are trying to do through technology is to create a civilization in which we can eliminate the peasant or slave base of past civilizations and free all of us for the creative management and enjoyment of our new way of life.

We are now well on our way toward fashioning such a civilization. This can be likened to an expanding pyramid in which technology is replacing drudgery, and sitting on top of it as it rises are the people who inhabit our new civilization—planning, guiding, coordinating.



In the long run, I believe we are creating what might be called a civilization of managers and are approaching a situation in which the coordination of the productive activity being generated will be fantastically complicated and challenging, but correspondingly rewarding. I would like you to think for a minute about today's management problems as compared with those of the early 1800's. Not much more than a century ago, there were really very few management problems because most people merely consumed what they produced and that was the end of it, but now, however, we have created a race of some two hundred mechanical men for every worker of the early 1800's and are no longer consuming locally, so to speak, most of our production. The problem of organizing the men and machines we now have and of coordinating and organizing the goods and services that they create has resulted in a serious management problem, and we are actually on the point of running out of managers.

This in reality is the problem to which our new technology must address itself if we are to continue to expand our productivity. The next step, which is essentially the one we have been talking about, is to extend the span of control of management. Today we can look at a machine shop requiring the services of fifteen machinists and one foreman. We can be proud of what we see because this shop is actually doing the work of one foreman and some fifteen hundred people in earlier golden ages; but now we can take another step. We can convert the machine shop so that it requires only the foreman, and we can convert the fifteen machinists into fifteen new foremen, which will let us in time build and operate fif-

Machines are limited to the past and the present. For the future, the human manager must still lead the way with his knowledge and imagination.

teen new-style machine shops and achieve another fifteen-fold increase in productivity.

This, then, brings us to the crux of our problem. We can see that our machines and our expanding technology are going to change our way of life, and change it by more than we can really imagine as we today think and talk about it. But what of our managers? Will they disappear or what? Maybe we cannot be precise about this, but there are certain generalizations that I think we can make.

First of all, we might look at our new production system. Just to simplify matters, we can consider the fifteen machine shops that replaced the one we had before. Each can run itself now and turn out all sorts of parts to satisfy inventory requirements. But what are the parts for? Where will the raw materials come from? Who wants the gadget the parts go into? How will it be used? How about the foreman? Does he know what to do if the machine gets sick? At every turn we need decisions that the machine shop and its computer cannot imagine and cannot cope with.

These are what we call management problems. Somewhere in our scheme of things a man must have imagination to plan, to organize, to coordinate, and to guide the destiny of our technological production units and the men who devise their memory. Our new manager with his fifteen foremen and their automatic shops is not running a labor gang of fifteen slaves building a pyramid but is controlling the output of fifteen shops. Each shop has fifteen machines and each machine can do the work of one hundred men. This adds up to 22,500 mechanized men for whom he is responsible. Do you doubt that he has management problems? Multiply situations like this by the hundreds of thousands and you wonder if there are that many managers and if we can really do the job.

Fortunately, there is an answer to this, although it is not a simple one. Just as we can devise production machines that create management problems, we can also devise machines that can help our managers cope with them. Normal management responsibilities of planning, organizing, coordinating, and guiding are complicated at best by the difficulty of assembling and digesting the various pieces of information on which management action is based. This is the job today of what we call management staffs. Tomorrow, however, the growth of staff groups, even if we expand them as fast as we can, will simply not take care of the problem. This again is a job for the machines, and, as you have heard, is one they can do admirably. The computers and information retrieval systems will form a sort of superstaff which can store untold information, recall it at will immediately, calculate various cases and possibilities and answer all sorts of complex questions with ease. The machines, then, will free management from its drudgery and pave the way for management decisions.

How do you tell when the machines stop and management takes over? The answer, I think, is simple. The province of the machines is: The past. They can remember, they can compute established relationships and do it all with incredible speed. But their only knowledge of the future is the mirror image of the past. The province of management is: The future, the development of new facts, new relationships, and new objectives. The difference is called imagination, or curiosity, or determination, or leadership. These qualities spell progress and I do not expect to see them emerge from our machines.

The point I would like to emphasize in all of this is that a manager's job is not in doing the kinds of things that machines can do but is one of planning, organizing, coordinating, and guiding, and that the tools he uses to do his job consist of machines, men, and ideas. Technology as it progresses has not in the past, and will not in the future, simplify his task at all, but instead will make life, if anything, more difficult for him than it is today. Our future managers will be faced with essentially the same management problems they have always had to deal with, but the job will be more complex, the challenge far greater, and the need for those who can meet the challenge, more urgent.

This brings me to the close of a somewhat philosophic discussion of management of the future as I see it. Certainly, as we look backward we can see that our past technology has greatly expanded our ability to produce goods and services but has at the same time placed an ever greater emphasis on the need for sound management to keep this all coordinated.

We are now entering what promises to be a bright new era, and tremendous forward steps seem to lie just ahead. I am certain that as we take these steps, we will create far more complex management problems than we have seen in the past, and equally certain that these problems cannot be solved without the development of machine methods to assist the limited supply of managers that will be available; otherwise, there will simply not be enough people nor enough time. Management will need every bit of help that it can get in terms of new information, calculating, and control systems.

Finally, I would like to express the view that if any one would like to worry about management of the future, he need not worry at all about technological unemployment in the management ranks, but had better worry about whether we will, in fact, be able to manage our new technological machine in such a way that we can keep the whole venture intact and keep it from collapsing of its own weight, like the dinosaur of an earlier age.

Presented at the A.I.Ch.E. Philadelphia Golden Jubilee Meeting.

The analogy between the problems of Systems Engineering and Management

Harry H. Goode, *University of Michigan*
Ann Arbor, Michigan

Systems engineering in both military and civilian fields is more and more recognized as a professional entity and, in the opinion of many, is essential for the design of large-scale systems. Questions have been raised concerning the applicability of systems techniques to the area of management. To answer such questions, one must determine whether the problems of management systems are similar to those in military and civilian system design. For this purpose, one must undertake a comparison.

To recognize the pertinence of such a comparison and joint consideration, of the problems of military and civilian system design, and those of management, consider the following statement of an important and increasingly pressing management problem:

"The rapid advance of technology on the one hand, and the long maturation time for research and development on the other, have created difficult management planning problems. The questions raised by these trends concern: a) how much effort to put into a product in present production when it is known that it will be replaced but the epoch of replacement is not known, b) where in the new technology is the best chance of payoff in terms of the development of a new product which will outsell the competitor's product. The possible errors and the cost of making them are clear: invest too much in the old product and too little in research and development and risk being outmoded by the competitor's product. Rely too much on research and development and make no serious production investment and risk ruin through loss of the market. If research matured faster and if inventions were scarcer, the problem would be less critical. If one could know what was developing in the competitor's laboratory and what his production plans were, one could make rational judgments."

This problem statement is converted at once into one concerning military systems and weapons development by changing the words "management" to "weapons system," "product" to "weapon," "outsell" to "defeat," and "competitor" to "enemy" and "market" to "war."

The problem just considered was a planning one. Similar parallel problems for the systems and management fields may be devised in the *control* and *organizational* areas as well as in the *planning* area.

If the problems are similar, it may be that the techniques for solution are similar and that one may gain insight into the one by examination of the other; i.e., examine the system design field, and make inferences about management. To develop this thesis, we shall set forth the general characteristics of the large-scale systems which present problems similar to those of management and outline the principles used for solution; to avoid pushing the analogy too far, we shall underline differences between system problems and management problems.

Large systems

The objects I have in mind when I discuss system design are the large-scale systems used in warfare, communication, transportation, etc. A missile system like the Nike missile system with its complex collection of airborne equipment; its tracking radars for following both missile and target; its computer for calculating the moment to fire, the course of the intercepting missile, and the moment of detonation; its switching equipment which decides which missile is fired at which target; the ground search radars which bring the information about the targets to the switching equipment so that such decisions may be made; the people who operate, supply, administer all of this; it is the design of this sort of collection of people and things I have in mind when I discuss system design. Other pertinent systems are the telephone system, air traffic control, air defense systems, vehicular traffic systems, etc. More and more such systems are required to satisfy the needs of our complex, mechanized civilization.

As one examines such systems as a class, a set of characteristics emerges which is present in more or less explicit form in all of them. Thus all of them are complex. *Complexity* is used here in the following narrow sense: A system is complex if a change in a single variable implies a change in many other variables. This leads to the result that one may arrive at a given state of system performance by many routes, exchanging values of one variable for those of another. While such interrelationships are useful in allowing a free manipulation of certain variables with a large amount of design freedom in the others, they produce the disadvantage associated with not knowing which of many possible variables causes poor performance when it occurs.

The tools which the system engineer has developed to deal with the problem of complexity include an evolving methodology relative to systems which goes by various names such as operations research, systems engineering, etc., but all of which are based on the scientific method; simulation, as a special form of mathematical modeling which is an essential step of these methodologies; and an extensive theory of servomechanisms. Aside from the scientific method, both of the other tools are less than fifteen years old in their organized stage of development.

Along with the bag of tools necessary for the analysis of complex systems, the systems designer has developed extensively one technique (among others which cannot be briefly treated) — the "feedback loop" — as a countering mechanism to the complexity inherent in the large systems under discussion. The feedback mechanism operates in such a fashion that a complex relationship between two variables causally related is made simpler by tieing the effect variable back to the causal one. Thus, to steer a ship across an ocean by deciding prior to its departure exactly what steering motions the helm will go through in order to get to the port of destination would be an impossible task because of the complex relationships (waves, wind, tides, etc., between the point of origin and the point of destination) which govern the ship's motion. However, if at every point during the voyage, a new reading is taken relative to the point

of destination, even in the face of a complex set of waves, winds, and tides, the ship may usually be made to arrive at its destination.

A second common characteristic of the large systems which we are discussing is that of multiplexity. This characteristic is descriptive of the fact that things are done not once, but many, many times, in large-scale systems. Frequently, the quantitative nature of the number of times that the thing is done yields a qualitatively different type of problem. It is, for example, one thing to say that one computes an insurance premium by a relatively simple formula, and quite another matter to say that the same formula must be applied to several million people. The resulting quantitative difference is the usual difference between chemistry and chemical engineering and between the research laboratory and the production line.

The tools which are employed in system design in connection with this multiplexity are based upon the logical design techniques of the digital computer designer. The logical designer, in turn, has based his consideration on those of Boolean algebra. The latter is an arithmetic of propositions which assures, if properly executed, the correct order of execution of successive operations in a system. The design philosophy for countering the characteristic of multiplexity is, of course, the employment of automatic equipment. When a required operation must be executed hundreds of thousands, or millions of times, a way is sought to mechanize the operation. There are certain principles which govern system design in the presence of multiplexity. One such principle is the requirement for a design search for the optimum point at which the information passing through the system should be standardized. Thus, in the telephone system, the input is standardized at the caller by requiring him to dial so that the system may handle electrical pulses immediately. In the post-office system, at the present writing, the public cannot be convinced of the desirability of standardizing input, and so the system must stand the burden of translating the handwritten address into the language of computers so that the mail may be handled automatically. This gives rise to an enormous burden in cost, as well as design, for the system. Careful attention to the point of standardization of information pays dividends in the resulting lessened complexity in system design.

Statistical inputs

An important distinguishing characteristic of large systems is the fact that the inputs are only statistically predictable; that is, one cannot say at any moment when an input to this system will occur, although he knows that in the long run the average number of inputs per unit time is close to some predetermined number. This characteristic of large-scale systems adds a great deal to the difficulty of design.

Of course, the design tools available for taking account of this characteristic of large-scale systems are based in statistics and probability. These have culminated in a discipline which has been dubbed "queueing theory." This theory addresses itself not to the event which is taking place, but to the time at which it takes place and the number of events occurring per unit time. The queueing problem arises because inputs to the system may occur at intervals of time which are shorter than the time within which the system can respond to an input. Thus, if only one telephone line is available, and a caller may initiate a call and prior to the end of his call another caller may arrive and demand service, the system is not able to respond to the requirements of the inputs. In this case, there are several alternatives available. One may increase the speed of the system by limiting conversation length, add telephone lines so that a waiting line will not form so readily, or allow callers to stand on line, or send them away. The choice will depend upon economics in terms of whatever is the coin of the realm relative to this problem: people, materials, money, effort.

A final characteristic of these large systems worth noting is that they have a certain integrity; that is, there is a purpose for which they exist. Thus, a large city is not a system by this definition, since there is no purposive action by all of the parts of the system. On the other hand, the large systems which are under discussion all have carefully delineated purposes. Because of this integrity and, in fact, in order to further it, the scientific method can be applied to their design. This method takes many forms and much time may be spent in its delineation, but roughly I recall for you that it involves observation, an attempt at generalization, the design of an experiment to see whether the generalization holds, subsequent modification of the generalization to take account of differences between experiment and preconceived notion, and so on around the loop, thus ever adding to knowledge. This method is applied in system design in the form of problem statement, suggestion of a solution to the problem, the design of a system (on paper) to satisfy the problem statement, a restatement of solution, and so on around the loop, ever improving the capability of the designed system for solving the problem.

Management systems, however, are not nearly as automatic as systems thus far discussed. There are more people in management with the consequent difficulties entailed in designing so as to match human frailty. Of course, as time goes on, the disparity between the amounts of automaticity in the two types of systems decreases.

A second important difference concerns what might be called the stationarity of the process governing the operation of the system. If it were not possible to statistically predict, for most of the time of operation, the

". . . management operates in a non-stationary atmosphere unlike the equilibrium of large-scale systems engineering."

average input to a telephone system, its design would be impossible. Thus, the total number of telephone calls to be made in any given period, on the average, is expected to increase only slowly, even though it is expected to increase. With the management system, the process does not have this aspect of equilibrium. The manager always finds himself predicting, or attempting to predict, in an atmosphere which the statistician calls a nonstationary process. In this case the underlying processes do not cause just random variations, but allow sudden shifts in direction such as wars, depressions, inventions, etc. Thus the application of queueing theory, while straightforward in a telephone system, has hazards in applications to management problems, unless these problems are organizational in nature.

Finally, there is the match with the human being. The effect of the human being on the large systems we have been discussing, while not negligible, is not explosive. Most times, one may expect that in a telephone system there will be erratic behavior by humans, but *not very* erratic. For example, one does not expect that everyone will yank his telephone out of the wall at the same time. In management systems, such stability may not be a valid assumption. Whole groups of humans may be motivated by emotion and act in a wholly unpredictable fashion; or if predictably, at least counter to the interests of the system, whatever those interests are.

Analogous applications of principles to management

For all of these differences, it is still worthwhile to discuss the similarities to determine what in system engineering may possibly throw light upon the operation and design of a management system.

It is clear that large-scale businesses have all of the aspects of a large-scale system and that the manager is essentially the systems engineer of the large-scale business. Thus we expect to find the characteristics of complexity, multiplexity, statistical input, and integrity present in the large-scale business endeavor.

We consider in some detail the similarities between the principles of system design mentioned above and management principles which are applicable on a similitude basis. Thus, in parallel with the feedback principles mentioned above—the response of the system designer to *complexity* in a system—the application of the control chart is of a similar nature in connection with management. Professor Likert and his coworkers at the University of Michigan, have been doing experimental work on the nature of the relationship between attitude toward the job and productivity. Part of his conclusion that management teams work best when they function as teams (that is, with a continuous flow of information relative to objectives) is similar to the feedback notion above.

As a counter to *multiplexity*, the systems engineer makes things automatic. Similar considerations apply to the management problem. We distill from the analogy the notion that the more complex the management problems, the greater should be the frequency of employment of automata for routine decisions. The principle of management by exception is an example of the recognition of the need for delegation of routine decisions.

The notion of *standardizing the inputs* at the proper point in the system is an organizational one. There is already a tendency, with highly mechanized organisms, to move out from the center to standardize inputs. Thus, integrated data processing is beginning to require the preparation of a standardized form for business information at the point of origin as opposed to the transmission of all manner of papers and consequent processing at the computer.

The principle of smoothing statistical inputs noted above in connection with "systems" transforms itself into the principle of smoothing the input to the business system as far out from the center as possible. Thus, we find Drucker underlining the differences between the production mechanism involving the assembly line and the automated production line. In the former case, one of the major efforts of management is concerned with improving the production process. In the latter case, the establishment of market demand becomes a more important function of management—an example of the smoothing effort of the manager.

Finally, the recognition of the *integrated* nature of the management system, as well as certain large-scale equipment systems, demands the use of scientific method in the approach to all manner of problems, whether these be problems of planning, organization, or control. The present move toward the employment of operations researchers is an implicit recognition of this demand. The same demand is yielding a better understanding on the part of management of the differences between fire fighting, and research on the causes of fire. Much management today (and most of it several decades ago) is based upon the solution of problems as they arise. The scientists' inquiry "What caused the problems in the first place?" had not been the habit of thought of the manager. Today, it is beginning to be recognized that while medals are given to those who carry people from the burning building, it is much more beneficial to so understand the causes of fire that no instances occur where medals must be given. In terms of ego satisfaction, this is a bitter pill to swallow, but it is easily recognized that the long-range job depends upon the application of such a principle.

A final problem for the management systems designer is that of the optimum unit size for subsystems. The rapid development of computing and communication equipments have made it necessary to reconsider the optimum size of a subsystem. In the past, optimum-sized units have operated as "profit centers." The reasons for these sizes, which are a product of evolutionary development, are that if they were much smaller they would not satisfy the general needs of the business for an integrated approach to the market, whereas if they were much larger the problems of communication and of digestion of information would arise. With the increased requirement for business data processing and for better communication methods, it becomes necessary and feasible to reconsider, in each industry, the optimum size of profit-center units.

Conclusion

We have reviewed some of the principles used for the design of large-scale systems, emphasized the differences between large-scale equipment systems and large-scale management systems, and translated some of the system design principles into form applicable to management. It is always true in "thinking by analogy" that care must be taken to avoid stretching the analogy too far. Further, resulting principles must be bent, stretched, and molded into a shape which will make them directly applicable to the new problems. Therefore, no attempt can be made here to reformulate the principles set forth in precisely the form in which they would apply to management problems. This step must be taken by the manager himself.

Presented at A.I.Ch.E. Philadelphia Golden Jubilee Meeting.

Machine processing of production data

. . . . . *an integrated approach to management problems*

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IT WOULD BE TYPICAL to define the responsibilities of management as the guidance, leadership, and control of a group of individuals toward some common objective. This indicates management's purpose but fails to provide an insight as to how results are obtained. Therefore, a better definition would include these five basic processes:

1) *Planning*—determining what shall be done. Planning covers a wide range of decisions, including the clarification of objectives, establishment of policies, establishment of programs, and determining specific methods and procedures.
2) *Organizing*—grouping the activities necesssary to carry out the plans into management units, and defining the relationships among the executives and workers in such units.
3) *Assembling resources*—obtaining for the use of the business the personnel, capital, facilities and other things needed to execute the established plans.
4) *Directing* — issuing management directives. This includes the vital matter of indicating plans to those who carry them out.
5) *Controlling*—seeing that operating results conform as nearly as possible to the established plans. This involves the establishment of standards, motivation of people to achieve these standards, comparison of actual results against the predetermined standard, and initiating necessary corrective action when performance deviates from the plan.

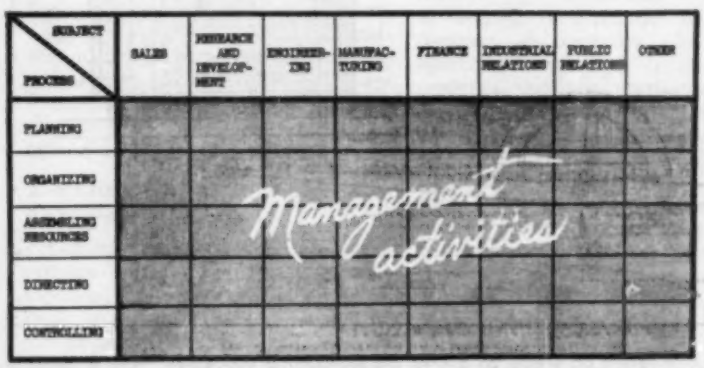

Figure 1. The work of various members of management can be divided into the five basic processes of management.

The work of various members of management is divided into specialized fields such as sales, research and development, engineering, manufacturing, finance, etc. Each of these may in turn be divided into the five basic processes of management previously noted (Figure 1). For example, the vice-president of engineering must plan, organize, assemble resources, direct and control, in the same manner as any other member of management. His problems may differ in degree, but they are interrelated and interdependent with those problems of the balance of the management echelons.

In the past, most discussions concerning management problems have been usually concentrated on one subject field, that is, finance, public relations, and so forth, and for the most part, the attempts to establish, clarify, and develop an answer to the problems of management have normally been directed in the more narrow channels. More recently, there has been considerable discussion concerning the development of an integrated approach to the problems of management. To my knowledge, to date no company has developed a fully integrated approach to the problems of management. The reason is that we are faced with a problem of analyzing and then developing a means of measuring and controlling a complex assortment of interacting groups of variously motivated entities in a flux of decision-making situations that

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comprise a normal company. The degree of the complexity involved is usually in direct proportion to the size of the organization.

We are in the midst of a major change in management philosophy—the change is gradual, and I feel that we are in danger of losing sight of what is really happening in business circles. In years past, management depended almost exclusively upon historical records for all its decision-making processes. Then came the advent of budgeting techniques and financial forecasting. Now we are in phases of development of long-range planning techniques together with the use of improved mathematical techniques—some of which are often referred to as Operations Research.

There are two reasons for this change. One is the increase in the scope and complexity of modern-day business, and the second is our increasing development of knowledge in the use of scientific management techniques.

Zay Jeffries, in an address given at the Case Institute of Technology about five years ago, said: "Our progress depends to a considerable extent on seeing to it that the simplifying processes move forward in approximate balance with the complicating processes. If this can be accomplished, then individuals with given ability can expect to go forward indefinitely without becoming casualties of their own complexity." I believe that Jeffries clearly stated the true basic problem of management.

Objectives of the Integrated Approach

In any discussion concerning an integrated approach to the problems of management, we must direct our attentions to the problem of what information is required to operate a business in a coordinated and profitable manner.

Good communication aids in coordinating the activities of management. Management must know promptly whether operations are proceeding in accordance with plans so that adjustments can be made when required. However, there is a wide variety of activities, particularly those of a detailed nature, that are impractical to plan too far in advance and coordination of these is achieved only when the personnel directing and performing them have current information upon which to base decisions.

Management is awakening to the realization that a business is controlled and directed by decisions based on information supplied by its data-processing system. It is realizing that major policy evolves from whole series of day-to-day decisions based on the information currently at hand. And it is awakening to the bare fact that much desirable information is not available.

The basic objectives in the development of an integrated approach to administrative systems are:

1) Development of improved management intelligence for use in decision-making processes,
2) The reduction and control of time spans,
3) Improved accuracy,
4) Increased productivity, and
5) Reduced costs of operation.

None of these basic objectives are new, but the advent of electronic data processing systems have given new life to this whole area, and we are now and will be seeking the proper application of integrated data-processing devices in order to take full advantage of interrelationships between the data problems of various segments of management and to recognize appropriately the dependence of a number of these segments on the same basic input information.

Planned Improvement

In attempting to devise a planned administrative systems improvement program for Lockheed, we recognized that we could not realize the desired results by merely studying, appraising, and converting our existing systems and procedures. We are faced with a research problem of considerable magnitude, and it could be solved only by an analysis of the requirements based upon a knowledge of systems parameters.

We found we had to solve this logical problem: *How can we best take the basic information from our day-to-day operations and process and distribute it so as to maximize our profits and minimize our costs?* The problem required that we devise a

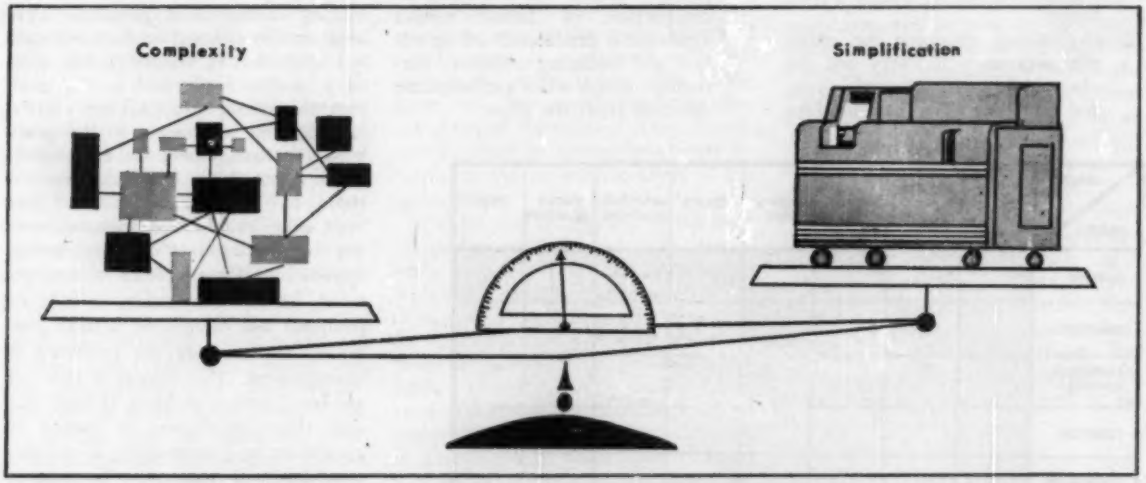

Figure 2. "Our progress depends to a considerable extent on seeing to it that the simplifying processes move forward in approximate balance with the complicating processes. If this can be accomplished, then individuals with given ability can expect to go forward indefinitely without becoming casualties of their own complexity."

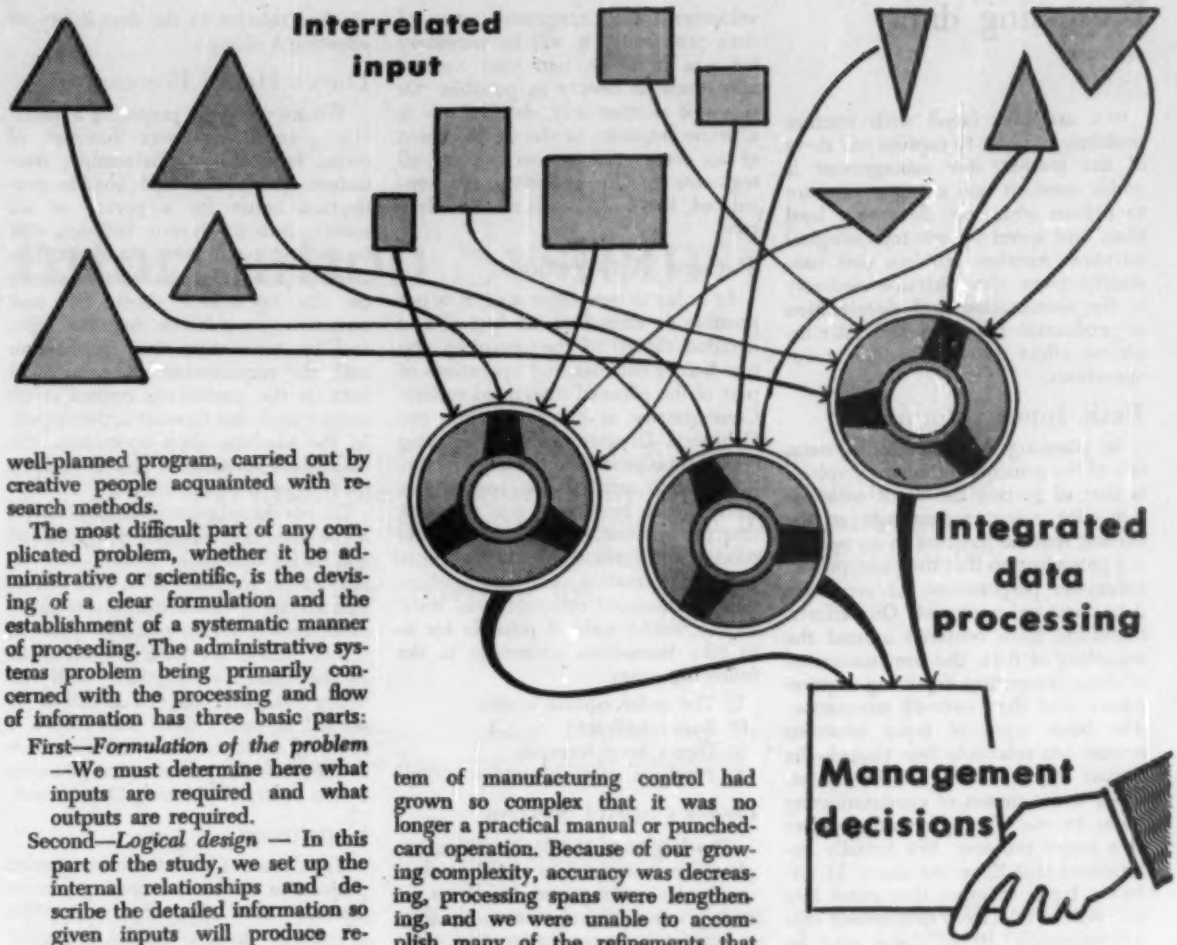

Figure 3. The proper application of integrated data processing devices takes full advantage of interrelationships.

well-planned program, carried out by creative people acquainted with research methods.

The most difficult part of any complicated problem, whether it be administrative or scientific, is the devising of a clear formulation and the establishment of a systematic manner of proceeding. The administrative systems problem being primarily concerned with the processing and flow of information has three basic parts:

First—*Formulation of the problem* —We must determine here what inputs are required and what outputs are required.

Second—*Logical design* — In this part of the study, we set up the internal relationships and describe the detailed information so given inputs will produce required outputs.

Third—*Detailed systems design*— This part is concerned with the techniques and the tools of the system—and spells out how the operations required in the Logical Design will be accomplished.

Regarding this as a logical problem, we discerned that it is not necessary that *each* person working on the formulation of the problem or the logical design have a detailed knowledge of the existing systems, accounting, manufacturing control, etc. The actual requirement is an ability to use research techniques, and an objective attitude which will not necessarily be influenced by existing systems.

Lockheed Approach to Integration

Our initial interests in an integrated systems approach at the California Division of Lockheed resulted from early studies to develop what improvements might be accomplished through the adoption of electronic data processing systems to our manufacturing control operations. Our system of manufacturing control had grown so complex that it was no longer a practical manual or punched-card operation. Because of our growing complexity, accuracy was decreasing, processing spans were lengthening, and we were unable to accomplish many of the refinements that our management felt were essential for satisfactory control of its operations. This is a prime example of one of the most important results of the introduction of electronic data processing systems in that it forced management to become aware of the need for integrated systems.

Manufacturing control is the means used by management to obtain economical and coordinated operations in carrying out a planned production program. It comprises planning of operational sequences, control of inventories, ordering, routing, scheduling and dispatching, so that the minimum of material, performance of machines and productivity of labor are controlled as to quantity, quality, cost, time and place. The establishment of sound manufacturing control practices are an essential prerequisite in the operation of an adequate system of accounts, including cost accounting and financial accounting, because while we think of production control as related only to materials, parts, man hours, etc., obviously proper accounting requires their translation to dollars and cents for financial purposes.

Our management found, as has been true of most managements, that they were strapped in attempting to apply adequate manufacturing control techniques because of the terrific amount of clerical effort required to maintain the desired system; in fact, manually it was an impossibility. The clerical problems were not so pronounced during the development of the initial production control schedules, but they rose when engineering modifications and change in anticipated production levels necessitated revision in the original schedule. Failure to revise these production schedules to reflect the frequent changes resulted in production control operations deteriorating into nothing more than a glorified expediting operation.

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We are also faced with another problem. In order to capture our share of the market, our management is under constant and extreme pressure to reduce costs, cut down our lead time, and speed up our technological advance. Another problem that constantly faces the airframe industry is the acceleration and deceleration of production schedules and their explosive effect on all segments of our operations.

Basic Input Information

In planning an integrated system, one of the principal problems involved is that of getting the input information into machine language at the earliest feasible juncture in an operating procedure so that the principles of automatic perpetuation of repetitive data may be employed. Our efforts, therefore, have centered around the recording of data, the communication of data, computing, reporting requirements, and their over-all integration. The basic types of input into our system are relatively few though the impact of the volume of these basic types and a means of communicating these to our data processing center is a major problem. We initially determined that there are about 21 different types of input that enter into our system and have determined that approximately 10 of these may be captured at the source. The others must be translated to machine language as a separate operation. Fortunately this latter group does not represent the bulk of our input media.

Based on the plan that I am discussing, it would appear that we would probably develop approximately 36 major magnetic tape files for use in this planned system. Eight of these 36 tapes will be generated by means of paper tape or punched cards which represent information captured at the source. Four of the 36 tapes will result from information that must be transcribed into magnetic tape as a separate operation, and 24 of the tapes will be generated internally within the system from information already captured. In other words, we are planning our system to take full advantage of the repetitive use of data. As you are aware, this is information that under a manual system is transcribed many times during the course of its eventual use.

I wish to emphasize that if you are to realize the maximum potential benefits obtainable through the development of an integrated system of data processing, it will be necessary for you to delve into your various operations as deeply as possible. Or to say it another way, depth study is a prime requisite to the development of an integrated system. Unless all segments of the operation are considered, the system will not be effective.

Present Applications

In order to get under way, it is not possible to formulate the logical and detailed design of the complete system before commencing operations of part of the planned integrated system. Consequently, at the present time, our California Division has four existing applications related to the manufacturing control area. These applications were chosen because it was apparent that the application of electronic data processing systems, the use of integrated information, and the application of advanced computational techniques would make it possible for us to take immediate advantage in the following areas:

1) The order control system
2) Base schedules
3) Direct hour forecast
4) Purchase parts inventory control

Order Control System

The largest of the four existing applications is in the area of the production order writing and it has as its end product the issuance of shop orders for both production and spare parts. Approximately 280,000 parts are recorded on magnetic tape for use in performing this operation. We estimate that based on current operations, this conversion to an electronic data processing system not only prevented a breakdown of our operating system due to sheer volume, but also increased our effectiveness and reduced our operating costs approximately $180,000 a year.

Base Schedules

The smallest application currently on machines is the preparation of detail schedules which set forth the day on which each ship and its major components that require deviation scheduling will go through each line position. The calculations involved are simple and could easily be performed by clerical methods. The justification for this job, however, is that the body of individual calculations are so great that it becomes a time-consuming, error-ridden, and expensive operation manually. Also, it is highly desirable to quickly publish new base schedules once management decisions have been reached relative to the desirability of effecting a change.

Direct Hours Forecast

We are presently preparing a quarterly direct man-hours forecast of direct fabrication, subassembly, continuous production and outside production hours for a period of six months into the future, for each cost center and department, by weeks. The standard man-hour elements, as shown on the operations sheet, by cost center, are recorded on magnetic tape, and by associating this information with the requirement and scheduled data on the production control order writing tape, the forecast is developed. In the machine shop operations, the man-hours forecast is also developed by type of equipment used.

The purchased parts inventory control application is completely programmed and is in operation. Anticipated results to be obtained from this operation are an up-dated material requirement record and a material position report which set forth requirements by lot quantities together with the usage for each lot, in addition to normal inventory data. This record is to be up-dated monthly and is to serve as the basis for procurement planning by the Material Planning Department.

Conclusion

Simultaneous with these integration projects in our manufacturing control area, we also have other integration projects under way within our company. For instance, we have a concentrated effort within our engineering branch at the California Division to develop means to improve the efficiency of our engineering operations in the areas of communications, utilization of manpower, scheduling, information retrieval, assessment and control. We anticipate that our efforts in this area will be most rewarding. In addition, a program of integration is under way within our finance and accounting areas to similarly integrate and increase our efficiency in these operations. Similar integration programs have been instituted at the other divisions comprising the Lockheed corporate entity.

We in Lockheed have recognized that to gain our ultimate objective, it is necessary that these projects be carried on simultaneously. Ultimately, through close coordination, and with an established objective, we are confident we will have developed an integrated approach to our management problems.

Presented at A.I.Ch.E., Philadelphia Golden Jubilee Meeting.

Information Systems

Increasingly complex technology, growing specialization make the problems of "keeping up-to-date" more difficult—and more vital. Here is an important examination of the techniques of storing information and of locating it for immediate use.

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The effective storage, retrieval and dissemination of written information has concerned the chemical engineering profession for years. This is because our progress and the soundness of that progress depend largely upon the interchanging of information—upon learning what goes on, not only in our own profession, but also in those fields of knowledge which are ever more and more being "overlapped" by chemical engineering.

In an attempt to disseminate new knowledge, technical information is being published at a rate which is doubling every ten to fifteen years. About 100,000 **technical** journals and some 300 **abstract** journals now exist and a recent review of trade, business and technical journals indicates that information pertinent to chemical engineers may now appear in as many as 500 American and Canadian periodicals, not to speak of European and other journals. Another illustration: the latest decennial index to **Chemical Abstracts** will consist of nineteen large volumes compared to the six smaller volumes of the decennial index of 1948.

But has our performance in using this information kept pace with its creation? The answer is a flat no. How many engineers can read—or even know of—each of the 500 periodicals which may contain information pertinent to their work? How many can review numerous abstract journals to find out which articles to read? For that matter, how many of us can be certain that some new development bearing directly upon our present work did not recently occur elsewhere—perhaps even elsewhere in our own organization? Instances have been documented of companies spending hundreds of thousands of dollars trying to solve problems for which solutions already existed in the literature. How many more instances, unrecorded or unknown, there must be of similar difficulties in utilizing recorded knowledge.

We in du Pont have the same problem as do others, the same problem which has generated all this interest. Pertinent information often arrives at a favorable point of use too late, incomplete, or sometimes not at all. For the past two years, we have been placing significant developmental effort on this facet of the total communications problem.

In the Engineering Department, this has been part of an over-all study of the engineering function, and we plan to handle, in our information system, not only technical but also administrative and control information for management's use. We wish to devise a system which will permit management more effectively to consider and control the diverse aspects of a large engineering operation. At the same time, we wish to provide individuals and organizations at every responsibility level in the department with the proper amount of accurate, up-to-date, pertinent information in the form required for each specific task, so that a more effective engineering job can be done by the department carrying out its duties.

Objectives and characteristics of information systems

This is a broad field. As you can see, it is not just filing, which is the

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Information systems

continued

storing of physical documents. We are concerned with the total field of information handling, the adequate performance of all facets of which calls for an effective information system. The objectives of such a system would be to gain increased profits or savings by improving personnel effectiveness and, for du Pont's Engineering Department, by optimizing design work in relation to each specific task at hand.

In order to carry on the functions of an effective information system, the following six specifications are essential:

1. The system must effectively retrieve stored information no matter what viewpoints and terminology are involved in originating and retrieving this information.
2. The system must correlate information as may be required so that information with the required degree of specificity may be supplied to the user.
3. The system must contain a maximum of valuable information and a minimum of information with low or questionable value to posterity.
4. The system must provide access to expert human assistance.
5. The system must keep its stored information up to date and accurate.
6. The system must answer the specific needs of information users without developing an excessive flow of paper.

Effectiveness of retrieval

The first of these six characteristics, effective retrieval of information, is the heart of any information system. If information cannot be retrieved, there is little point in working on the other objectives. Thus effectiveness of information retrieval has occupied us during the first phases of our work.

AIR CONDITIONING	Frequency of association
Ventilating; vents	45 %
Refrigerating; refrigerants	27
Air	27
Heating; heat; heated	27
Power	27
Standards	27
Cooling	18
Heat transfer	18
Steam	18
Temperature	18
Compressors	10
Dehumidifying	10
Drying	10
Ducts	10
Exchanging	10
Health	10
Moisture	10

Figure 1. A list of associated terms in order of frequency of association under the main term in question

CLASSIFICATION

1 Pump
- 1.1 Bucket Pumps
- 1.2 Centrifugal Pumps
- 1.3 Grease Pumps
  - 1.31 Air operated
  - 1.32 Drum transfer
  - 1.33 Electric
- 1.4 Oil Pumps
  - 1.41 Circulating
  - 1.42 Transfer

Figure 2. Classification—an arrangement of retrieval terms which assemble and separate concepts.

Theoretical background. There are two basic approaches to the problem of how to put away information and get it back again. The first approach is search harder for the desired information, which has been stored away with relatively few "handles" for retrieval. This is the approach which has been attempted for centuries and which has become increasingly ineffective as the volume and complexity of information have grown. The second approach is to increase effectiveness at the input side of the system, that is, we can provide more handles for retrieval, handles which may be useful from numerous viewpoints and with different terminologies.

Even had the first of these two approaches not been tainted with failure, the second approach, more effective indexing at the input side, should be carefully considered for large information systems. For such systems, the output-input ratio is high. We have found examples even in relatively small systems where, for every item entered into the system, there are many items referred to by users. Hence, the place to expend effort is on the relatively low-volume input. We must provide each document with index entries such that the user will have a high probability of retrieving it, no matter what his viewpoint or terminology, if the document is pertinent to his needs.

The indexer must thus be provided with a "remainder list" of words generally associated with those words already used by the originator and indexer in connection with any given document. For example, if an author speaks of "distillation," the "distillation remainder list" should include such words as rectification, evaporation, boiling separation, etc. The indexer may choose from the list those words which will be appropriate additional index entries for the document at hand. A descriptive name for such a reminder list is "word-association matrix."

A word-association matrix can be produced mechanically on computer or conventional punched-card tabulating equipment. A loose but adequate basis for deciding if words are associated is whether or not they appear in the past as index entries for the same document. Thus, such a matrix includes the viewpoints and terminologies of all earlier originators and indexers of information. It provides for each term in the vocabulary of index entries a list of associated terms, listed in order of frequency of association under the main term in question (Figure 1).

Accordingly, during indexing, the indexer first notes, as index entries, those pertinent terms which appear in the document being indexed. He then adds implied terms based upon his own knowledge; these will usually be synonyms and broader generic terms. He then refers to the word-association matrix. For each term under which he has already indexed the document, he checks the association list. From the list, the indexer selects additional terms appropriate in describing the document. It can be seen that the indexer must be a competent technical generalist.

ALPHABETICAL INDEXING

Abbreviations	16 – 17
Acknowledgements	10
Aids in report writing	13 – 21
Authors	10
Bibliography	6, 8, 10, 11, 12
Book citations	19
Chemical formulas	13
Closing reports	11

Figure 3. Conventional alphabetical indexing is the second retrieval principle.

Accordingly, we can solve the basic problems of terminology and viewpoint as rigorously or as lightly as we may be able to justify on an economic basis, because we have numerous degrees of freedom in using the word-

association matrix. Some of these degrees of freedom include the extent and frequency of updating the matrix (based upon more recent indexing), how extensively the indexer uses the matrix, how lengthy we make each matrix list (i.e., do we cut off lower frequency associations?), etc. By making decisions on each of these different variables, we can vary significantly both the costs and effectiveness of the indexing operation. Obviously, for a document with any given value to posterity, some optimum combination and use of these variables is best.

So much for developing the indexer's ability to solve problems in terminology and viewpoint. What *form* of index will best utilize this ability? There are three general types of indexing and retrieval principles which have been developed for storage and retrieval of information. The first of these is known as classification (Figure 2). A classification is an arrangement of information retrieval terms which *assemble* concepts into classes according to an *order of likeness* and *separates* them according to an *order of unlikeness*. It is apparent that as the body of collected information grows, it becomes necessary to institute more and more classes, subclasses, sub-subclasses, etc.

The second retrieval principle is conventional alphabetical indexing, with which we are all familiar (Figure 3).

The third retrieval principle is known as concept coordination (Figure 4), which is the generic name for various systems which analyze items (documents, drawings, etc.) into a set of terms or index entries, and provide for the retrieval of any particular item as the intersect of two or more terms. In such a system, any item (such as a person, a document, a machine, a process, etc.) is indexed under each of the individual concepts which describe it, not under combinations of concepts. The combinations are freely generated (coordinated) by the searcher during retrieval. Thus, just as innumerable English words can be constructed from the twenty-six letters of the alphabet, a great number of items can be described in a concept coordination system with a relatively small vocabulary. Because permutations and combinations of concepts need not be indexed, the problem of system size is solved.

There are two classes of concept coordination systems, distinguished by their diverse use of "system units" (Figure 5). System unit means an individual card, section of tape, or the like, which is manipulated during retrieval operations. The first class of concept coordination system has *one system unit per document*. This class includes McBee card and most IBM systems. The last class of systems has *one system unit per vocabulary term or concept* and this class includes Batten Card systems and coordinate indexes, which have significant advantages in index size, flexibility, and operating efficiency when large collections of documents must be handled. This is because in such systems *only* those system units pertinent to the question need be searched, whereas the first-mentioned type of systems requires in principle the searching of the entire file.

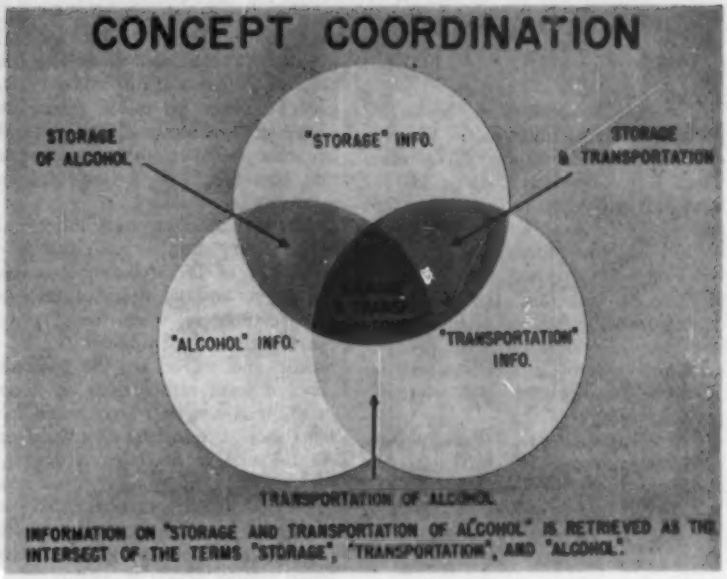
CONCEPT COORDINATION
STORAGE OF ALCOHOL
"STORAGE" INFO.
STORAGE & TRANSPORTATION
"ALCOHOL" INFO.
"TRANSPORTATION" INFO.
TRANSPORTATION OF ALCOHOL
INFORMATION ON "STORAGE AND TRANSPORTATION OF ALCOHOL" IS RETRIEVED AS THE INTERSECT OF THE TERMS "STORAGE", "TRANSPORTATION", AND "ALCOHOL".

Figure 4. Illustration of document principle III—concept coordination, generic term for systems which analyze documents, drawings, etc.

The physical size of an index system of the second class (or selective type) of concept coordination depends almost completely upon the size of the vocabulary of indexing terms. Based empirically upon the experience of eight operational concept coordination systems (the largest containing about 100,000 documents), the relation between total number of documents D in the collection and the total number of indexing terms, the vocabulary V, is approximately:

$$V = 4170 \log_{10} (D + 730) - 11{,}620$$

and

$$\frac{dV}{dD} = \frac{1810}{D + 730}$$

continued on next page

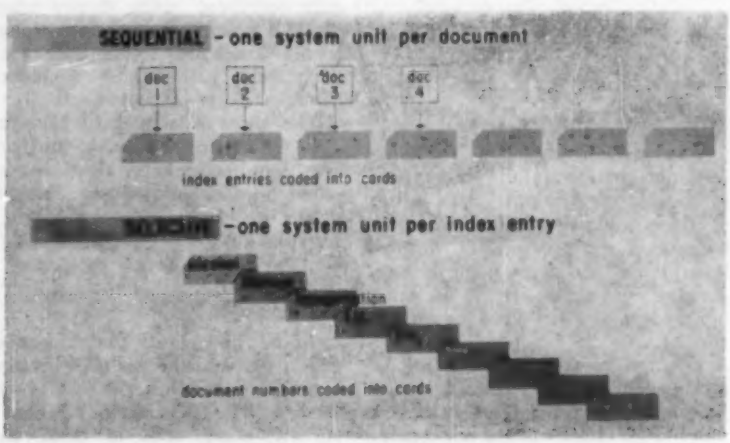
SEQUENTIAL - one system unit per document
doc 1
doc 2
doc 3
doc 4
index entries coded into cards
SELECTIVE - one system unit per index entry
document numbers coded into cards

Figure 5. The two classes of concept coordination systems distinguished by their diverse use of "system units."

Information systems

continued

Thus it can be seen that vocabulary growth becomes quite slow. The vocabulary contains about 5200 terms when the collection contains 10,000 items but only 9300 terms for 100,000 items.

How do the three principles of indexing and retrieval, that is, classification, alphabetical indexing, and concept coordination compare in their abilities when considering the production and use of a word-association matrix and the providing of relatively deep indexing?

Classifications gather narrow concepts together under broader concepts, but the subject in question must be entered under all known appropriate classes. This would result in an unmanageably large classification and the usual practice is to skimp on the number of entries. When large collections of documents must be handled, resulting in additional subordination within classes, subclasses, and sub-subclasses, the problem of categorization is intensified. If relatively complete retrieval is required, a widespread search through the entire classification is thus necessary to insure that all categorizations of the concepts in question have been located. This is not practical.

Figure 6. Syntactics—One peculiar problem in concept coordination—Is it venetian blind or blind Venetian?

Classification is a suitable retrieval tool only when any of the following conditions prevail: (1) the subject field to be indexed is narrow in its scope, (2) the classification will be used only by a small group of people who can learn it well and agree upon its categorizing conventions, or (3) the number of documents involved is relatively small.

When developing conventional, alphabetical indexes, retrievability will be poor unless the subject at hand is indexed generically to the appropriate degree. For example, during retrieval of information on "liquid-liquid separation," the searcher may fail to find data indexed under "distillation." The problem is intensified when combinations of concepts are involved. Should care be taken to index information under all possible headings, the index becomes unmanageably large. In practice, therefore, only a few main subjects are indexed.

Problems of viewpoint and terminology exist when using concept coordination to the same degree as when using conventional alphabetical indexing. Fortunately, when using concept coordination, the problems can be attacked and solved on the *individual concept* level rather than on a *combination of concepts* level or *total systems* level. Production of a word-association matrix becomes a practical, feasible consideration rather than merely a theoretical one. Also, with concept coordination, deep indexing is practicable because of the relatively small system size.

Use of concept coordination does, however, bring about one peculiar problem of its own—syntactics, or word order. If syntax is disregarded, we may erroneously equate "cooling water" to "water cooling," or even "venetian blind" to "blind Venetian" (Figure 6). That is to say, if we look for the intersect of the concepts "blind" and "venetian," we may find *both* "venetian blind" and "blind Venetian" discussed in the documents to which we are referred. The problem of syntactics may be solved by setting up a new concept in the vocabulary (for example, "blindness") or it may be solved by attaching role indicators to our index entries. For example, we can tag the concept "water" with a role indicator noting whether "water" is passive or active in the operation. Then, if we want "cooling water" (i.e., water for cooling), we will search only for those index entries which consider water as an active agent. Less than a dozen such role indicators can adequately handle the syntactical problem.

The three principles of classification, alphabetical indexing, and concept coordination may then be compared on the basis of equal retrievability or effectiveness as shown in Figure 7.

	Classification	Alphabetical Index	Concept Coordination
Cost	Very high	High	Low
Simplicity	Very poor	Poor	Very good
Adaptability	Very poor	Fair	Good
Compactness	Poor	Very poor	Good

Figure 7. A comparison of three general types of retrieval principles.

Results of work

In the Engineering Department, we began our work in this field by using concept coordination on technical reports. The department's technical reports, about 4600 of them, have been indexed using concept coordination techniques. Indexing depth per report is approximately twenty index entries, or access points. The index consists of a coordinate index, double-dictionary-type book with identical pages in each of the two independent sides (Figure 8). When using the index for retrieving, the searcher chooses a combination of concepts expressing his "question," opens the side of the index to the word describing the more important of the concepts under question, and opens the other side of the index to the second most important concept. He then matches report numbers entered under each concept involved. The numbers which match will be those of reports pertinent to the combination of the two concepts searched. These matching numbers may then be matched with a third concept, etc. After obtaining the report numbers which are indicated to be pertinent to the question at hand, the searcher refers to a list of report titles, arranged in numerical order, to choose the most pertinent reports for further perusal (Figure 9). You will note that this title list includes under each title the index entries for that particular document, thus providing a condensed abstract.

Some 400 copies each of the double-dictionary index and title list were printed early this year and distributed not only within the Engineering Department but throughout the company, especially to file centers and libraries. Experience has been very favorable. References to engineering department technical reports have increased significantly over references which resulted from the earlier index, an alphabetical subject heading list. It is indicated that the retrievability of information from the new index is two to four times greater than for the old index and, of course, there is still plenty of room for improvement. Even so, we are now making a wealth of information more available to our engineers. The original cost of producing the information contained in these reports was literally millions of dollars. It is assumed that the value of the information in a given report has a five-year half life, the present-day value of this information is still some 40 percent of the original value. It would take little improved utilization

of this tremendous storehouse of knowledge to pay many times over for the cost of the index.

The Engineering Department's Engineering Information Center is now beginning to apply concept coordination to process-type information contained in the records of construction projects, and our construction workload is more than $150,000,000 per year. We are now instituting a system which will permit us to retrieve, from past experience, process information significant to a current project. We will identify those proposed actions which are duplicates of previous actions and will do them essentially "by rote." We will identify those proposed actions which are similar to previous actions and will undertake only modifications. We thus plan to place our emphasis in manpower and brains upon those subjects which are truly new or which have most economic potential for improvement. We also plan to coordinate other Engineering Department work (such as, engineering studies, evaluations, etc.) with construction project work.

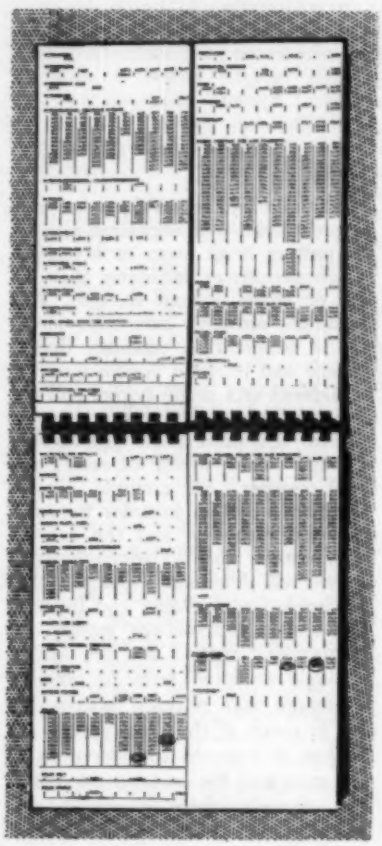

Figure 8. Example of coordinate double-dictionary index.

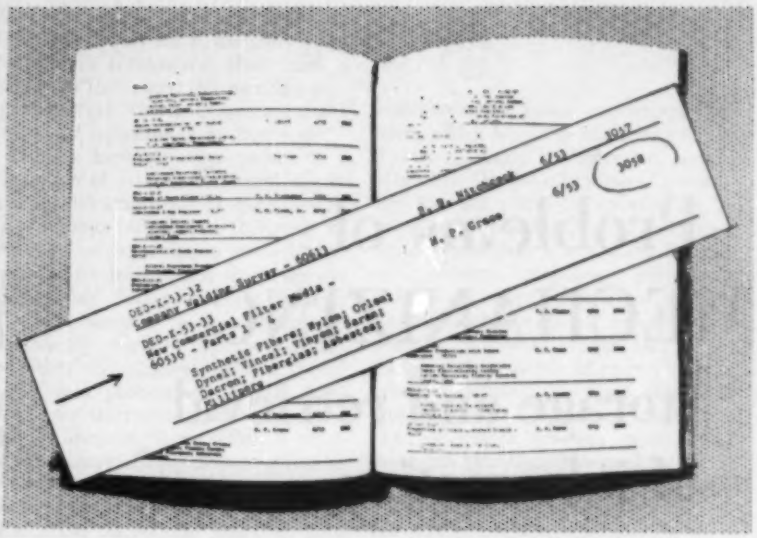

Figure 9. A list of report titles arranged in numerical order for the searcher to choose the most pertinent titles for further study.

The information-handling work of our management research study group includes a number of other programs. For example, we must continue efforts to mechanize the retrieval of information. We are watching developments in this field closely and are optimistic that suitable machines will be developed before our Information Center grows to a size which would be unwieldy with manual techniques.

Other information system characteristics

An effective information system needs several other characteristics (Figure 4). Most of the problems involve only methods developments, rather than research, and are not really too difficult. The major areas in which we are now concentrating concerns the necessity to correlate information and to predetermine its value to posterity.

It is undesirable for the user of information to have to do his own digging through numerous retrieved documents to glean the bits of information pertinent to the subject at hand, i.e., to do his own correlating. This is especially undesirable for large systems. We must find a way of doing a large amount of this correlation in the information system.

Two types of correlations appear: general and specific. *General* correlation of information, which develops the "state-of-the-art" for a given field of knowledge, can be performed by experts in individual fields of knowledge once the bits and pieces of information necessary for correlation can be retrieved effectively from the total store of information. The resulting correlation is then an indexable item and can thus be made available to later searchers. *Specific* correlation involves collections of information concerned with specific physical facilities and may be useful in conveying the correlated information within and among construction projects especially. These specific packages can thus serve as the "raw material" for time, cost, and quality control of work performed throughout the life of a project. Considerable work has been expended in the Engineering Department on development of these specific correlation methods.

We are starting a program designed to develop objective criteria for determining the value to posterity of various types of information and documents. It is apparent that not all documents have a value to posterity which will justify their inclusion in an information system, no matter how low the input costs may be. In order to choose more effectively those documents or types of information which will give us the greatest return for our money, we must develop criteria for determining the value of these documents or types of information. Operations Research techniques are being employed in this work. We have no results, proved sufficiently significant to report at this time, but there seems to be no reason why some empirical yet objective criteria for the value of information cannot be developed.

Presented at A.I.Ch.E. Meeting, Philadelphia, Pa.

Problems of MECHANIZING storage and retrieval of information

A rapid survey of Data Information systems pointing to the manner in which each one attempts to decrease the cost of storage and to increase the speed of retrieval by the development of codes, by the dense packing of codes in a storage medium, by the physical arrangement of the storage media, and by various methods of prefiling or organizing the information.

Mortimer Taube
Documentation, Inc., Washington, D.C.

Devices for mechanizing the retrieval of information have one major characteristic in common with all other machines—they exist only to reduce the cost in human effort of performing various tasks and—often—to perform those tasks faster than can be done by unassisted human effort, which is another way of saying: at a reduced cost. When the characteristics of information retrieval machines are examined, it will be apparent that these characteristics represent not the abilities to perform tasks which are qualitatively different from those performed by existing devices or systems, but only the ability to perform the same tasks at different rates, i.e., at different costs. For example, anything which can be selected in one search of the store by the most highly developed internal logic of a large general-purpose computer, can be selected by a card sorter, which selects on a single column at a time, by making as many successive searches as are required by the complexity of the question.

In other words, once the functions of a storage and retrieval system have been set forth, any device to perform such functions will differ from any other in cost. There are no qualitative differences among the indexing or searching potentials of different devices and systems. By recognizing that the differences are differences in cost, it is not implied that such differences are not important. The aim of mechanization of storage and retrieval systems is to make possible the reduction of cost (in human time and capital investment) of storing and retrieving information. It remains as a task of theory to analyze the requirements and operating parameters which determine total cost, and to provide against decisions based on only part of the relevant data, e.g., search speed per bit in abstraction from input cost, programming cost, etc.

With this general background in mind, that machines provide no magical solutions to the problems of information retrieval but only faster and cheaper ways of performing tasks already solved in principle, let us examine first certain fundamental considerations concerning the relationship of storage to retrieval.

A storage and retrieval system in its simplest terms is an organized method for putting items away in a manner which permits or facilitates their recall or retrieval from storage. This definition, although essentially circular, is intended to establish that a storage and retrieval system must be considered as a single system and not as a storage system plus a retrieval system. It is unfortunate that we lack a single word which expresses the total complex. For example, a communication system includes transmitters and receivers, and the over-all requirements of a communication system will determine a compatibility or correlation of design and function between its transmitting aspect and its receiving aspect. But the lack of a single accepted term to describe a storage and retrieval system has led in much of the literature on the subject to separate considerations of the store and the retrieval apparatus. For example, there is considerable literature on microreproduction of documentary material which treats the retrieval of an item from the store

as an afterthought and not a basic design requirement of the store itself. Similarly, there is much material on systems and devices for retrieving information which fails to consider the effect of the logical and physical design of the store on the design and performance of the retrieval apparatus.

It is obvious that the simplest way to put something away is to pile it in a heap. The easiest way to fill a warehouse is to put material away as it comes in without regard for organization or order until the warehouse contains a solid cube of stored material. At the same time, it is also obvious that finding a particular item in such a warehouse might entail emptying the whole warehouse (as a woman empties her pocketbook) and physically handling and examining every item in it. At the other extreme we might design a warehouse so that every item in it was preloaded on a conveyor running through the warehouse, with no item in the path of any other. Such a warehouse would be complex and expensive, but it would make possible push-button retrieval of any item.

Thus, it becomes obvious that the method of retrieving information is inseparably bound to the method of storing that information, because how information is stored largely determines how one must attempt to retrieve it. This is true not only of mechanized systems but also of manual systems.

Matching the store against the question

The selection of an item from a store, if performed directly by a human being, involves an act of recognition. The human being who searches a store does so with a question in his mind which he matches against the properties of the items in the store. The degree of similarity which would constitute a match between properties of items in the store and the requirements of a question in the mind of a human searcher cannot be exactly specified. Any physical item can be characterized by an infinite set of properties, any subset of which must function as the basis of human recognition and selection.

The substitution of mechanical recognition for human recognition seems to depend (1) on the possibility of describing an item in the store with a finite set of properties; (2) on the possibility of using codes to represent such properties; and (3) on the possibility of specifying the conditions of a match or failure to match on an all-or-none basis. This last condition states the requirement for converting the human recognition that "this is similar to that" into the machine recognition that "this code is equivalent (or is not equivalent) to that code."

It then becomes appropriate to a discussion of information machines to discuss characteristics of data-processing systems which are relevant to problems of information storage and retrieval, for information machines are indisputably data-processing devices, of which there is an increasing and bewildering variety now available.

Within the general field of automatic data processing or data handling, we distinguish three types of systems involving three different types of automata: (1) data-computation systems and computing automata; (2) data-transmission systems and communication automata; and (3) data storage and retrieval systems and "look-up" automata. An integrated data-processing system can involve all three types of data systems; but for any particular requirement one or another design characteristic is usually most important. A communication network can employ computer-like devices as adjuncts for coding and decoding; a computer can have a limited look-up capacity as an internal store; and a storage and retrieval device can have teletype output (communication) and computer-type comparators. Even if an operating system exhibited characteristics of all three systems, it would still be necessary to distinguish the three types in the same sense that we distinguish a conductor as capacitor, resistor, or inductor even though it always has the properties of all three.

There are five characteristics of data-processing equipment which seem to have direct relevance to the information storage and retrieval problem:

1. Dense packing of codes which reduces the size of the store.
2. Rapid matching of the store against the question which reduces the time of search.
3. The "erasibility" of the store which permits updating and elimination of obsolete information.
4. Matching many-termed questions against the store in one search, i.e., an increase in the degree of parallel access as compared with ordinary punched-card equipment.
5. The ability to program a single search to select on the basis of products, sums, and complements of classes as well as temporal order.

Since in storage and retrieval systems the size of the store and time of search seem to be of major importance, devices which have the characteristics in 1 and 2, must be accorded serious attention. On the other hand "erasibility" and the ability to update may be important only for rapidly changing systems and may constitute a disvalue for systems requiring permanent storage or even long-term storage. Characteristics 4 and 5 are obviously relevant to rate of search, i.e., by increasing the number of code elements read in parallel, the time of search can be reduced. In other words, the time of search for any given sized store can be reduced by packing codes denser and denser and moving such codes past a reading head faster and faster. Contrariwise, the packing density and rate of transport can be held constant and search time can be reduced by providing more reading heads.

Effect of environment upon information storage and retrieval systems

The environment in which an information storage and retrieval system operates has significant effects upon the system. The environment of a storage and retrieval system is the totality of those conditions which individually and collectively establish the requirements which must be met by the system. In a discussion of these conditions emphasis shifts from input to required rate of input; from searching or logical operations to required rate of searching or operating; from output to rate and form of output; from the logic of matching a question against the store to the size of the question and the number of questions which must be matched against the store in a given period of time; from maximum efficiency of coding to acceptable noise ratio; from the distinction between item codes and term codes to the determination of the absolute and relative sizes of the collection of item codes and term codes, etc.

A description of the environment states the requirements which must be met "efficiently" by a system or a device. These requirements can still be considered in theoretical or general terms; but some consideration of them seems to be necessary to establish the design requirements of any system or device. It is not likely that any particular storage and retrieval device

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Problems of Mechanizing

continued

will be the "best" for all kinds of environment. But this does not mean that the choice of a particular device or system for a particular environment is arbitrary. Rather, the choice must be carefully considered, for the stakes in the game are high.

Terms and items

In any storage and retrieval system, we deal ultimately with two kinds of entities: terms and items. An item is the thing we put away, a report, an abstract, a personnel file, a piece of hardware, a patent, an engineering drawing, a specification, etc. A term is a name, description, classification, numerical value or in general, any discriminator by which we characterize an item so that we can recall or retrieve desired items from a store. If each item in the store had only one characterizing term, like a number or like a name in the telephone book, retrieving a desired item from the store would be a relatively simple business—we could go immediately to a fixed position in the store to find any item. But when an item is characterized by a set of terms, any one of which or any combination of which may be used as a retrieval code, then it becomes impossible to locate the item in a fixed array by any of its terms. This creates the requirement for a searching apparatus which will search for an item characterized by a set of codes and reveal the address of that item.

Since there are only two entities, terms and items, there are only two ways to group codes in a storage and retrieval system. We can make a physical record for each item and enter the applicable term codes on that record (conventional grouping); or we can make a physical record for each term code and enter the applicable item codes on that record (inverted grouping). Logically the two systems are identical as indicated by Figure 1 (a) and (b).

But there is an enormous difference in the efficiency or search times of the two methods. Conventional grouping of codes requires that a search be a sequential examination of the total file; but inverted grouping involves only the selection and comparison of item codes on a selected set of term cards, namely those which match the terms of a question put to the system.

This situation can also be illustrated with reference to mechanized searching by comparing punched-card sorting systems with punched-card collating systems.

Searching systems

Searching is performed with a sorter by making several successive sorts until all items coded by a certain term or terms have been selected, that is, sorted out from the rest of the deck. Changing the column selector in the sorter and selecting the cards from the proper pocket constitute setting up a question in the reading head of a piece of apparatus, and this question is matched successively against codes in the store. It is assumed that each item is represented by a card or set of cards on which is grouped the term codes characterizing that item.

With standard punched-card equipment (unless superimposed punching or wiring is used), the term codes in the question must be matched against specified fields on the item cards. For example, a simple sorter "sorts" cards column by column as determined by setting the column selector in the sorter; and the IBM "101" machine which can search many columns at once must be programmed to search in the proper columns for term codes in the question. [The "101" can be wired to search for a single code in any of a number of fields.] In such a system the total file must be sorted for each search.

Collating systems

The inherent inefficiency of linear search has so far precluded the successful application of punched-card searching to collections of any significant size which cannot be divided into mutually exclusive classes; but several relatively successful punched-card installations have been organized for collating rather than searching. In setting up a system of punched cards for collating as contrasted with searching, grouping of items by terms is employed rather than grouping of terms by items. Table 1, in which the numbers indicate items and the letters indicate terms, illustrates the two forms of grouping.

Table 1.

Searching	*Collating*
1 A M N O	A 1 3
2 B C D T	B 2 3 9
3 A B M R	C 2 5 9
4 L N O P	D 2
5 C G H K	F 6
6 F G M P	G 5 6 8
7 L P R T	H 5
8 H K L S	K 5 8
9 B C R S	L 4 7 8
etc.	M 1 3 6
	N 1 4
	O 1 4
	P 4 6 7
	R 3 7 9
	S 8 9
	T 2 7

When collation is used as a matching technique, item codes collected under one term are matched against item codes collected under another term. In effect one group of item codes becomes the question which is matched against the other group considered as the store. It should be apparent that collation does not require the search of the total store but only of those item codes grouped under the terms of the question.

However, with standard collating equipment a considerable price must be paid for this decrease in search time. A collection of 1,000,000 items indexed by an average of 20 terms would require a file of 20,000,000 cards. With 10,000 terms in the vocabulary the 20,000,000 cards would be arranged in 10,000 groups averaging 2,000 cards in a group. Since a standard collator feeds 240 cards per minute from each feed, the collation of two terms (asking a two-termed question) would average between 10 and 20 minutes. This is an appreciable reduction from the time required for a sequential search of the total file but there are some penalties which must be faced which reduce radically the efficiency of standard collators as information searching devices.

First, the size of the store must be increased enormously to permit prefiling items (cards) under every term by which they are indexed, in this instance, from 1,000,000 to 20,000,000. Second, collators only work on arrays maintained in fixed numerical or alphabetical order. Hence item cards must be filed (posted) to each term array and maintained in that array in a fixed order. Third, cards matched by the collator and selected as answers must be refiled in proper order. If the selected cards are to be retained as an answer or are to be matched against other groups, they may have to be duplicated so that the array from which they are selected initially can be restored to completeness for other searches.

Magnetic-tape systems

In an examination of magnetic tape systems, of course, one immediately considers computers. One of the difficulties of evaluating any general-purpose computer in the abstract for

information storage and retrieval is that such devices are extremely flexible and are made up of many different components. A total system may employ cores, drums, discs, tapes, and punched cards, and there may be more of certain elements than others depending upon the requirements the computer is literally "put together" to satisfy. Any organization which has available to it a general-purpose computer may use some of its components and subsystems for the storage and retrieval of information. This creates the problem of determining what percentage if any of a computer's cost should be charged against the storage and retrieval system, or even what characteristics or capacities of a computer are relevant to this specialized use as opposed to other uses served by a computer.

Magnetic-tape systems are linear systems which provide rapid transport of tape past a reading head and high density storage of code elements. Magnetized dots on the tape can be packed 500 to the inch and multiple channels and reading heads can be provided for various widths of tape. The width of the tape and the number of reading heads determine the number of code elements which can be read in parallel.

Although most experiments with magnetic-tape devices have grouped term codes under item codes with the groups randomly arranged on the tape, the high packing density and high transport speeds of tapes have encouraged experiments in both inverted grouping of codes (item codes under term codes) and in multiple entry of item groups. In other words it is possible to use tapes as a linear searching system or as a collating system just as with punched cards. In addition, searching time can be reduced by entering an item and its term codes in several different places on a tape or on several different tapes, just as many cards for an item are filed in a catalog. This method of multiple filing on tapes, while difficult, is not impossible. However, multiple filing and multiple access are best provided with systems using discrete elements like punched cards.

It is necessary to emphasize that the inefficiency of sequential searching is a matter of principle because there are those who hope to overcome this inefficiency by spending more and more dollars for data-processing equipment with faster and faster rates of search. The situation here has been well summed up by R. A. Fairthorne:

"The rate and cost of access to a required item is proportional to a fractional power of the number of items to be searched. With linear access, such as single speed tape or film searching on a single reel, it is directly proportional to the number of items. Therefore however slow multi-level (multi-dimensional) access may be with a small collection, and however fast linear scanning, there will be a certain size of collection over which the multi-level access will always be the faster. This is beginning to dawn on the engineers, who are now graduating from the ribbon to the scroll book. In due course they will triumphantly announce their rediscovery of the bound volume of pages" *(1)*.

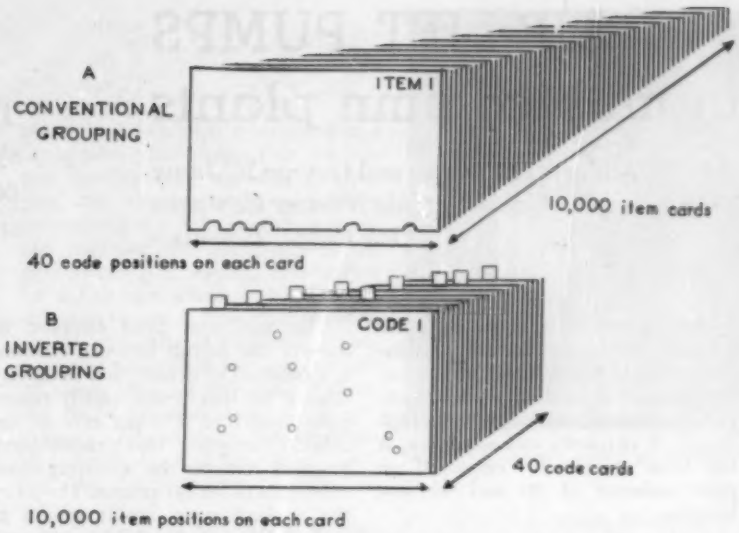

Figure 1 (a) and (b) Conventional and inverted methods of grouping codes in a retrieval system. The former requires a search of total file; the latter involves comparison of item codes on a selected set of term cards.

Conclusion

The fact that a computer can be used as a storage and retrieval device if considerations of efficiency are disregarded, does not establish computers as universal information-handling machines any more than the self-propelling property of steam shovels makes them universal vehicles of locomotion. Machines are designed for special purposes; the design and logic of any individual machine should reflect such purposes. If a complete abstraction is made from purpose and efficiency, there remains no basis for design, that is, no basis for the logical and physical arrangement of parts and functions which constitute a machine. Hence the concept of a universal machine is in essence contradictory.

Undoubtedly a great deal of money and ingenuity has gone into the task of investigating the adequacy of accounting machines, statistical machines, computing machines, and the like for the storage and retrieval of information. Even though this effort has not resulted in successfully operating mechanized systems, it has not been wholly or even largely useless. From it we have learned the design requirements of special-purpose storage and retrieval devices. At least one of these devices is now in the development stage. It promises to give access in minutes to million-item stores even when the items are characterized by as many as twenty terms. Furthermore this device and others like it are not required to store elaborate programs and carry out complicated sets of instructions. They are matching machines and promise to be relatively inexpensive and simple to operate. Thus it can be expected that the storage and retrieval of information will yield rapidly to effective mechanization once the logic of the operation is understood, and the design of the hardware we develop is determined by that logic.

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Presented at A.I.Ch.E. Meeting, Philadelphia, Pa.

AIR-LIFT PUMPS in multicolumn plants

Andrew H. Fowler and George R. Jasny
Union Carbide Nuclear Company
Oak Ridge, Tennessee

This versatile air-lift pump system is particularly adapted to hazardous or abrasive solutions.

Here is a method of obtaining liquid transport between columns of a multicolumn plant through the use of air-lift pumps. The method provides complete automatic control with a high degree of simplicity and reliability. It has been successfully employed on pulse columns of 20 and 40 foot lengths.

The problem

When a long column is needed for a particular exchange system, it is usually necessary to set up several shorter columns operating in series. The available headroom is often the deciding factor in selecting the individual column length. The result is a multi-column system as shown in Fig. 1. The flow rates of the two streams at the left in the figure are regulated and so indicated by the valves in the line. The designations "bottom," "top," "upper," and "lower" refer to the relative positions when the system is considered as one long column made up by stacking the individual columns. The pumping problem consists of pushing the lighter liquid into the bottom of each column and lifting the heavier liquid to the top of each column.

The additional head required to transfer the liquids between columns is a function of density and inventory ratio of the liquids and usually ranges from twenty to fifty per cent of the column length. This requirement uniquely matches the operating characteristics of air-lift pumps. However, the application of air-lift pumps in such a way as to obtain automatic operation has received little attention in the past.

The system

An arrangement for obtaining automatic transfer with air-lift pumps is shown in Figure 2. First, the heavy phase which leaves the bottom of the upper column will rise only a portion of the necessary height to enter the top of the lower column. Air is injected near the bottom of the connecting line to "lift" the heavy phase the remaining height. Now the desired flow rate between columns is determined by an independent flow control on the heavy phase leaving the lowest column in the plant. This flow rate is then maintained between each pair of columns by a controller which is sensitive to the heavy phase level in the lower column and adjusts the flow rate by varying the amount of air injected in the heavy phase "lift."

Similarly, the desired light phase flow rate is governed by an independent flow control on the light phase entering the bottom column. For each pair of columns, then, the light phase overflows from the top of the lower column and must be "pushed" into the bottom of the upper column. To accomplish this, a loop is put in the connecting line and air injected at a constant rate into the rising portion of the loop. If sufficient headroom is available, it is only necessary to place the top of the loop a few feet higher than the top of the column. Otherwise a few feet of back-pressure, obtained with a back-pressure regulator or dip leg, are necessary. The self-regulating nature of this arrangement eliminates the need for a controller; all of the liquid entering the overflow is simply transferred to the next column.

The equipment

The air-lift pump itself, shown in Figure 3, is the simplest of devices. In

continued

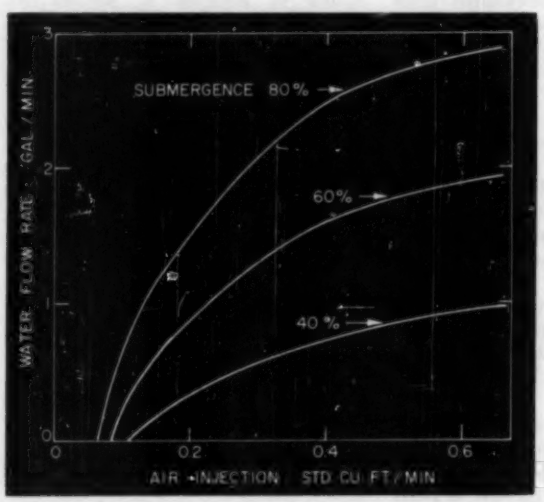

Figure 4. Typical flow curves for a half-inch pipe air lift

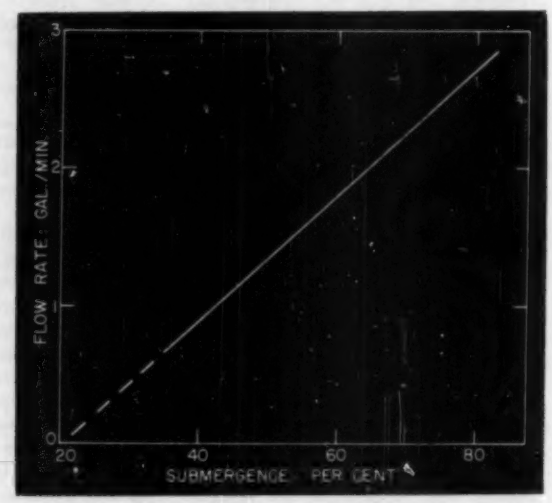

Figure 5. Water flow rate for a half-inch pipe with a constant air injection of 0.5 std. cu. ft./min.

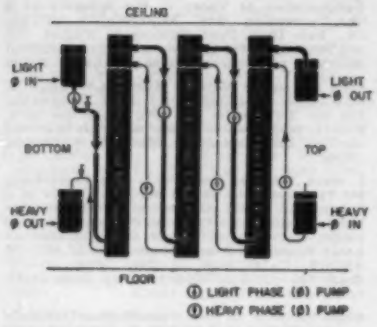

Figure 1. Multicolumn flow diagram

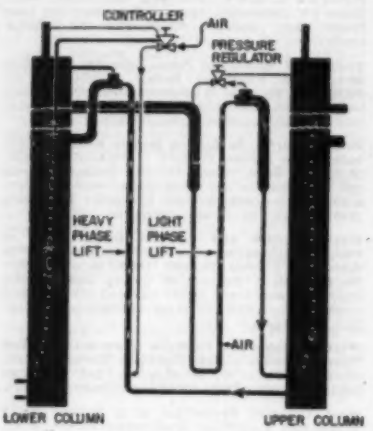

Figure 2. Columns with air-lift pumps

principle it is a pipe submerged in a liquid with a connection near the bottom for injecting air. For a given pipe size, the important parameters determining the flow are the air-injection rate and the percentage of the pipe submerged. Typical flow curves for a half-inch schedule 40 pipe are shown in Figure 4. Note that an initial air injection rate is required to produce any water flow and that the useful range is about six or eight times this initial injection rate. G. W. T. Kearsley *(1)* and A. V. Chamberlain *(2)* have shown that for higher injection rates the water flow actually decreases.

In Figure 5 the flow rate is plotted against per cent submergence to show the strong influence of submergence. It is this characteristic that provides the self-regulation of the light phase pumping circuit. This circuit is shown in detail in Figure 6. Note the enlarged section at the top of the loop which allows the injected air to separate from the liquid and pass off through a pressure regulator. The pressure in the enlarged section is adjusted so that there is sufficient head on the light phase to force it into the bottom of the column.

The heavy phase level controller shown in Figure 7 is a diaphragm-operated valve of somewhat unique design. There is small clearance around

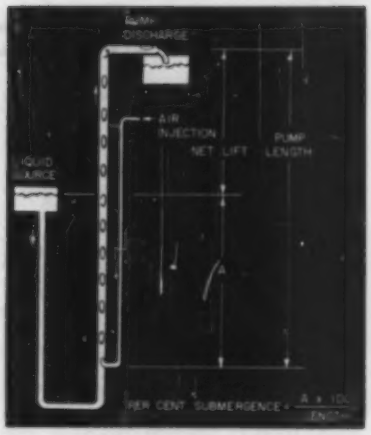

Figure 3. Air-lift pump geometry

the valve stem which functions as an air bleed to a dip tube. The back pressure from the dip tube operates against the diaphragm thus making the air flow to the "lift" sensitive to level. The design also allows for operation under pressure by connecting the opposing side of the diaphragm to the column top.

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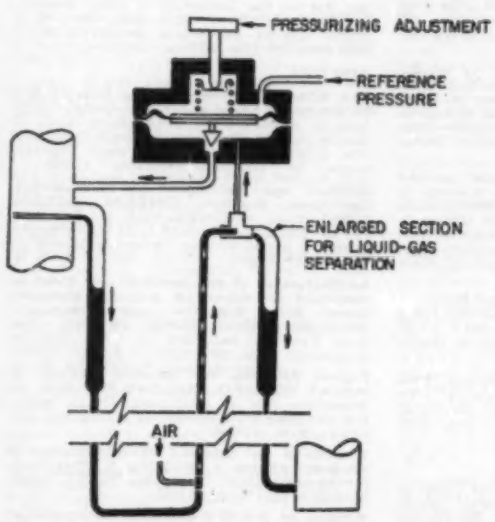

Figure 6. Phase separator and pressure regulator

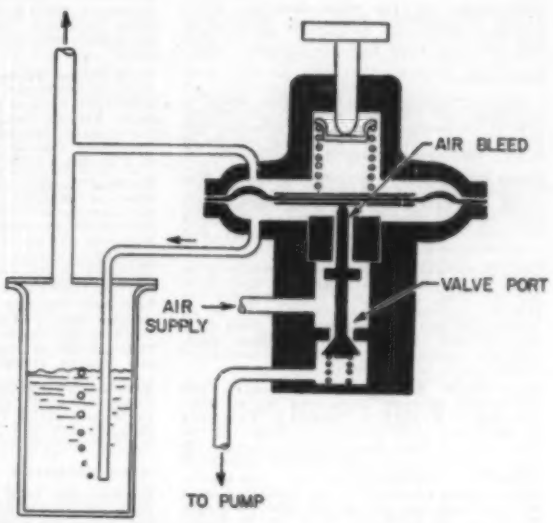

Figure 7. Level controller

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Light hydrocarbon pyrolysis

....*the effects of pressure and equilibrium approach*

Effect of pressure and equilibrium approach on product distribution and ethylene yield —performance data from commercial coils.

H. C. Schutt, *Consulting Engineer,* Boston, Mass.

Pyrolysis of the hydrocarbon feed stock is the primary process phase of an ethylene production unit, and its operation has a profound effect on the whole plant performance. High conversions and ethylene concentration in the pyrolysis products at sustained high yields from a given feed stock are generally the objectives of the cracking operations. They require a judicious postulation of the design premises as well as the rational application of chemical engineering theorems in the apparatus design.

The design basis normally stipulates the coil-outlet pressure and the depth of conversion commensurate with the general plant performance requirements. The olefin yields are then derived from a product distribution pattern corresponding to the operating pressure.

Another important consideration having a bearing on the strict validity of the distribution pattern of the conversion products used as a design basis, is the thermochemical equilibrium of the reactions predominating in the conversion process. Homogeneous gas-phase reactions in industrial-scale operation rarely reach equilibrium; in fact, they should proceed only to partial equilibrium in order to avoid formation of undesirable by-products by secondary reactions accompanied by a corresponding depreciation of the principal product yield. The approach to equilibrium also consitutes a basic reactor design variable as well as a criterion for optimum commercial plant operation, from the standpoint of both economy and operability. The degree of approach to equilibrium will depend upon the reactor or pyrolysis coil design in which velocity, rate of heat

input commensurate with the reaction rate, and the heat intensity distribution are major considerations.

When studying the vast amount of published information on hydrocarbon pyrolysis at atmospheric pressure, one can explain variations in conversion or yield data, in most cases, by consideration of the approach to equilibrium of the principal reversible reactions involved. Performance comparisons of such reactor systems as regenerative heaters, moving bed or fluidized solid heat carrier, partial combustion of reactant, sometimes referred to as autothermic cracking, etc., with the conventional tubular cracking furnace, do not show appreciable differences in product distribution and yield of olefins when evaluated on the basis of a common denominator of partial pressure, degree of conversion, and equilibrium approach.

Commercial plants have been built for relatively high pyrolysis (coil outlet) pressures, as high as 35 lb./sq. in. gauge in an attempt to reduce plant costs by saving in compression requirements. This effort was made without duly appraising the effect of pressure on the operation of the pyrolysis cycle. The more recent large installations employ a reaction coil-outlet pressure in the order of 10 lb./sq. in. gauge and give better plant performance. The investment cost is not markedly different inasmuch as the savings in compressor cost for the higher pressure operation are offset to a great extent by the increase in equipment requirements for the pyrolysis and quenching cycle when designed for the same degree of flexibility and on-stream efficiency, the principal criterion being the equilibrium approach.

A commercial pyrolysis coil, equipped with sufficient thermowells permitting numerous temperature measurements to establish the true temperature gradient, is a much better apparatus than laboratory or pilot plant reactors for obtaining reliable information on the product distribution over a wide range of conversions. Long steady-state operation, frequent and accurate stream analyses, and complete material balance are all inherent in the operation of a modern production unit.

It is of particular interest to verify the effect of the above-mentioned basic design variables, i.e., coil outlet pressure and equilibrium approach, for the pyrolysis of ethane, and to draw certain conclusions on the reaction mechanism while considering kinetic aspects of the over-all conversion.

Table 1.—Ethane Pyrolysis at 8-10 lb./sq. in. gauge in Commercial Cracking Furnaces

Furnace Feed						
C_2H_4, Mole %	0.6	2.1		0.7		0.6
C_2H_6	99.3	96.7	←	98.7	→	99.2
C_3H_8	0.1	1.2		0.6		0.2
Avg. Mole wt.	30.07	30.17		30.12		30.08
Steam Dilution						
Mole/100 mole feed	15.0	15.0	20.2	20.0	20.0	40.3
Coil Outlet Conditions						
Pressure, lb./sq. in gauge	8.5	9.5	8.2	8.5	8.5	8.3
Temperature, °F.	1496	1502	1512	1520	1520	1532
Conversion Products C_4 and lighter						
H_2 mole %	31.8	32.5	35.1	36.9	37.1	37.8
CH_4	3.8	5.2	4.2	4.9	5.1	6.5
C_2H_2	0.2	0.2	0.2	0.2	0.2	0.3
C_2H_4	30.5	32.0	33.5	34.4	34.3	35.8
C_2H_6	32.6	28.9	25.6	22.1	21.7	18.0
C_3H_6	0.6	0.5	0.7	0.8	0.9	0.9
C_3H_8	0.2	0.3	0.2	0.2	0.3	0.2
C_4+	0.3	0.4	0.5	0.5	0.4	0.5
	100.0	100.0	100.0	100.0	100.0	100.0
Avg. mole wt.	20.20	20.40	19.20	18.55	18.60	18.15
Mole/100 mole feed	147.4	149.7	154.4	158.9	158.8	162.5
C_5 + fract. incl. carb. wt. % of feed*	1.0	1.9	1.7	2.0	2.2	2.0
Expansion	1.478	1.502	1.550	1.597	1.597	1.633
Conversion; % (Ethane disappearance)	51.7	55.3	60.0	64.6	65.2	70.5
Equilibrium Approach	0.324	0.364	0.407	0.505	0.513	0.541
Ethylene Yield; wt. % of ethane converted	80.9	79.8	80.8	79.2	78.2	77.2
Process Steam; lb./lb. of ethylene made	0.216	0.210	0.253	0.237	0.238	0.448

**Adjusted on basis of material and hydrogen-carbon balance.*

Procedure in commercial operation

Performance data for the normal, low-pressure operation (Table 1) cover the range of conversions which may be encountered in commercial operation during the process of bringing the unit up to the desired production level. This involves the simple operational procedure of setting the flow of reactants, raising the coil outlet temperature and making some adjustments in the flow of process steam as the degree of conversion increases. For the maximum production of ethylene, a high conversion per pass is desirable and a sacrifice in yields is accepted commensurate with the value of the feed stock. However, for the sake of continuity of operation, i.e., the avoidance of coke formation and deposition in the cracking coil, the equilibrium approach is usually held below a certain value depending on the depth of cracking. The steam dilution is increased when operating at high conversions, thus reducing the partial pressure of the reactant and conversion products, and in this manner the appropriate equilibrium approach is maintained, at which intolerable coke deposition in the coil should not occur.

Performance data for a system operating at relatively high pressures, i.e., 27-28 lb./sq. in. gauge, are given in Table 2. It will noted that greater amounts of process steam are used, especially at high conversions, in order to avoid excessive side reactions and coke formation. A reduction in hydrocarbon flow may become necessary because of excessive pressure drop and too high an equilibrium approach at an intermediate point in the reaction coil.

The fluid flow patterns, as dependent on the reactant velocity and the heat intensity distribution, are approximately equivalent for the reaction coils, and no pronounced difference in the conversion mechanism or permissible equilibrium approach can be attributed to the fluid film conditions. Therefore, the variations in product

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Pyrolysis

continued

distribution are principally the result of the differences in operating pressure and the depth of conversion or equilibrium approach prevailing in the homogeneous gas phase.

When using the thermochemical equilibrium of the reversible reaction $C_2H_6 \rightleftarrows C_2H_4 + H_2$ as a criterion either in reactor design or the analysis of operating data, it is, of course, essential to refer to the most accurate values of the equilibrium constant. Experimental data are only available for a relatively low temperature range *(5, 8)* which agree reasonably well with theoretical values based on the free-energy function as defined by the third law of thermodynamics. Kilpatrick, *et al. (3)*, in the course of their work on Research Project 44 of the American Petroleum Institute, have determined the equilibrium constants for the hydrogenation reactions of mono-olefins over a wide temperature range based on thermodynamic and quantum statistical data, and their correlations seem to agree with the most reliable experimenal data of earlier investigators.

Figure 1 gives the equilibrium constant as a function of the temperature for the dehydrogenation of ethane, propane, and higher molecular weight saturated hydrocarbons over the temperature range, the concern in commercial pyrolysis. These equilibrium relationships are based on the well-established thermodynamic properties of hydrogen and the hydrocarbons involved, i.e., heat content and free-energy functions, also developed as part of API Research Project 44 and can be used with confidence by the chemical or design engineer.

The equilibrium constant, K, is thermodynamically defined by the following equation:

$$\ln K = -\frac{\Delta F^\circ}{T} \times \frac{1}{R}$$

where ΔF° in cal./mole represents the change in free energy for the dehydrogenation reaction; T, in °K., the absolute temperature and R, the gas constant, at 1.9872 cal./°mole. The partial pressure ratio of the decomposition products and the reactant is expressed as follows:

$$K_p = \frac{{}^nC_2H_4 \times {}^nH_2}{{}^nC_2H_6} \times P$$

where n is the mole fraction of the constituent in the total reactant stream and P the absolute pressure in atmospheres. Equilibrium is designated by $K = K_p$ and the equilibrium approach is simply the ratio $\frac{K_p}{K}$.

Variations in product distribution pattern

Figure 2 has been prepared to show the variation in product distribution for the two sets of commercial operating data. The increase in methane production is of particular significance and will be discussed later in conjunction with reflections on the reaction mechanism. In general, the variations in the product distribution pattern are quite large and when comparisons of various pyrolysis methods or operations of coil-type reactors are made, pressure and equilibrium approach must be considered in order to prove the real merits of one system or reactor design over the other.

Figure 3 clearly indicates why the lower pressure operation is preferable. The conversion efficiency, i.e., the yield of ethylene from the ethane converted, is considerably lower for the higher pressure operation, especially at a high degree of conversion, and the steam requirements are considerably higher in order to maintain a reasonable equilibrium approach at which real continuity of operation of the reactor can be maintained.

When analyzing the plant costs and the operating expenses for the operation at different pressures, it can be readily established that the savings in plant investment costs for the higher pressure operation are relatively small and absorbed by the higher operating costs within a short time, i.e., two to three months' operation. Furthermore, the pyrolysis coil or furnace design for the higher pressure operation involves the problem of maintaining an appropriate time-temperature relationship for a given conversion per pass without excessive pressure drop. The coil-outlet temperature should be higher than for the lower pressure operation, unless the steam dilution is

Table 2.—Ethane Pyrolysis at 27-28 lb./sq. in. gauge in Commercial Cracking Furnaces

Furnace Feed					
C_2H_4 mole %	1.5	1.1	2.3	2.0	1.8
C_2H_6	96.8	96.4	96.0	96.2	96.4
C_3H_6	1.4	1.7	1.2	1.2	1.4
C_3H_8	0.3	0.8	0.5	0.6	0.4
Avg. mole wt.	30.25	30.36	30.24	30.26	30.26
Steam Dilution					
Mole/100 mole feed	30.0	45.0	65.3	74.8	94.0
Coil Outlet Conditions					
Pressure, lb./sq. in. gauge	27-28				
Temperature, °F.	1490	1505	1516	1520	1525
Conversion Products					
C_4 and lighter					
H_2 mole %	29.8	32.5	34.6	35.8	36.9
CH_4	5.8	6.9	8.2	9.2	10.9
C_2H_2	0.2	0.2	0.2	0.3	0.3
C_2H_4	30.1	31.8	33.9	34.1	33.8
C_2H_6	32.8	27.1	21.6	19.1	16.6
C_3H_6	0.7	0.8	0.7	0.7	0.7
C_3H_8	0.2	0.2	0.2	0.2	0.1
C_4 +	0.4	0.5	0.6	0.6	0.7
	100.0	100.0	100.0	100.0	100.0
Avg. mole wt.	20.5	19.65	18.77	18.34	17.80
Mole/100 mole feed	144.8	149.7	155.0	157.0	160.1
C_4 + liquid incl. carb. wt. % of feed*	1.9	3.0	3.8	4.9	5.9
Expansion	1.455	1.509	1.564	1.588	1.622
Conversion; % (Ethane disappearance)	50.9	58.0	65.2	68.8	72.8
Equilibrium Approach	0.49	0.57	0.68	0.74	0.78
Ethylene Yield; wt. % of ethane converted	79.6	77.9	75.0	72.5	69.8
Process Steam; lb./lb. of ethylene made	0.457	0.619	0.832	0.931	1.150

**Adjusted on basis of material and hydrogen-carbon balance.*

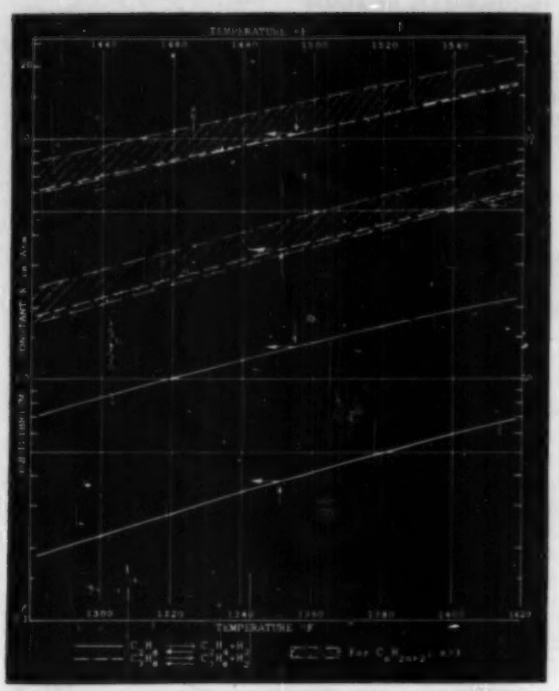

Figure 1. Equilibrium constant for dehydrogenation of low molecular weight paraffins.

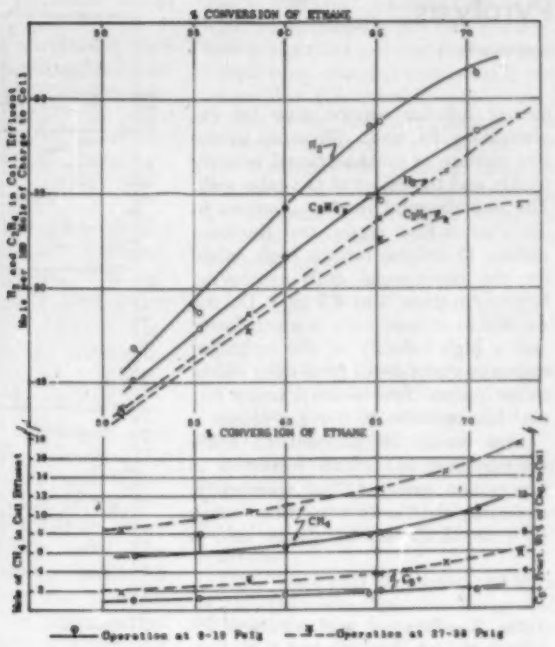

Figure 2. Product distribution in commercial ethane pyrolysis.

of such magnitude as to produce the same partial pressure of the reactant, which would considerably increase the furnace cost and also the operating expenses, and thus defeat the primary purpose of choosing a higher operating pressure. While the pyrolysis furnace can be properly designed for the higher pressure, its flexibility as to the range of conversion and ethylene output is limited.

Data for propane and *n*-butane

The low-pressure operation is practically mandatory for processing higher molecular weight hydrocarbon feed stocks. Higher conversions and ethylene yields can be obtained in sustained, continuous operation if the equilibrium approach does not exceed 65% for a moderate and 50% for very high conversion and if the corresponding coil-outlet temperature is obtained without intense heat application to the reactant when it is in an advanced state of conversion. Representative commercial operating data are given in Table 3 for propane and normal butane. The $C_2H_6 \rightarrow C_2H_4+H_2$ equilibrium approach is also for these stocks the criterion for the conversion per pass which can be maintained without encountering excessive coke formation. The olefin yields are maintained up to a high degree of conversion as long as equilibrium is not too closely approached; in fact, the whole product distribution pattern is valid only for a certain equilibrium relationship.

A high conversion per pass is advantageous, especially for the pyrolysis of normal butane, because the olefin yield and production increase markedly as the general product distribution pattern indicates, the validity of which is, of course, dependent on the equilibrium approach. The main problem in the design of the reaction coil for the conversion of higher molecular weight hydrocarbons is the attainment of the appropriate temperature level, in view of the reaction rates which increase with the molecular weight of the reactant. Accurate rate data are prerequisites for the correct design of an operable pyrolysis coil.

Pressure and equilibrium approach, which are, of course, interrelated, have a pronounced effect on the product distribution pattern, as is evident from the correlations given in Figure 2, and it may be concluded that the reaction mechanism is sensitive to these variables. On Figure 4, the methane production in ethane pyrolysis is shown in correlation to the equilibrium approach and seems to exhibit a consistent dependency, irrespective of the system pressure. The product distributions given by Kinney and Crowley *(4)* for a wide range of conversions at 1500°F. have been evaluated and the methane yield has been derived in relation to the equilibrium approach, as is also indicated on Figure 4. These experimental data which were obtained at a system pressure that was essentially atmospheric, seem to confirm that the methane formation is primarily a function of the equilibrium status or approach. The conversion data presented by Kinney and Crowley also show that the reaction:

$$C_2H_6 \rightarrow C_2H_4+H_2$$

is not reversed at the temperature level of 1500°F., which confirms commercial operating experience; the ethane continues to decompose but the hydrogen-ethylene and ethane concentration ratio remains essentially at the equilibrium value, once it is reached.

The methane yield in commercial plant operation is only verifiable up to approximately 75% equilibrium approach, the upper limit of the pyrolysis coil operability with respect to coke formation. The evidence that the methane yield for the commercial coil is generally less than for the experi-

continued on next page

Pyrolysis

continued

mental tubular reactor may be explained by the wide difference in the flow pattern or cross-sectional velocity profile and the effect of the tube wall. The experimental reactor operates in the viscous flow region and the tube surface to volume ratio is high, while for the commercial coils employing large tube sizes, 3 to 4.5 in. I. D., the surface to volume ratio is much lower and a high velocity in the turbulent region is maintained, producing essentially "piston" flow of the reactant and real homogeneity of the gas phase.

One would be inclined to relate the variations in methane formation to the system pressure, but commercial operating data over a pressure range of 8 to 35 lb./sq. in. gauge do not indicate a consistent increase of the methane concentration in the reaction products with pressure for a given degree of conversion.

Table 3.—Propane and n-Butane Pyrolysis at Low Pressure and High Conversion

	Propane	*n*-Butane
Furnace Feed		
C_3H_8 mole %	0.5	
C_3H_6	98.1	0.1
n-C_4H_{10}	1.4	97.2
i-C_4H_{10}		2.5
C_4H_{12}		0.2
Avg. mole wt.	44.22	58.13
Steam Dilution		
Mole/100 mole of feed	45	32.0
Coil Outlet Conditions		
Pressure, lb./sq. in. gauge	8.5	9.1
Temperature, °F.	1495	1500
Conversion Products		
C_4 and lighter		
H_2 mole %	13.1	11.4
CH_4	37.4	37.5
C_2H_2	0.3	0.4
C_2H_4	28.9	28.6
C_2H_6	7.0	6.4
C_3H_6	6.8	11.1
C_3H_8	5.4	0.6
C_4H_{10}	0.2	2.2
C_4H_8	}	}
C_4H_6	} 0.9	} 1.8
	100.0	100.0
Mole/100 mole feed	176.3	215.2
C_5 + liquid incl. carbon wt. % of feed	10.3	13.0
Expansion	1.815	2.236
Conversion of Key Const., %	90.2	95.0
Equilibrium Approach		
$C_3H_8 \rightleftarrows C_3H_6 + H_2$	0.49	0.51
$C_2H_6 \rightleftarrows C_2H_4 + H_2$	0.02	0.26
Process steam: lb./lb. of C_2H_4 made	0.56	0.33

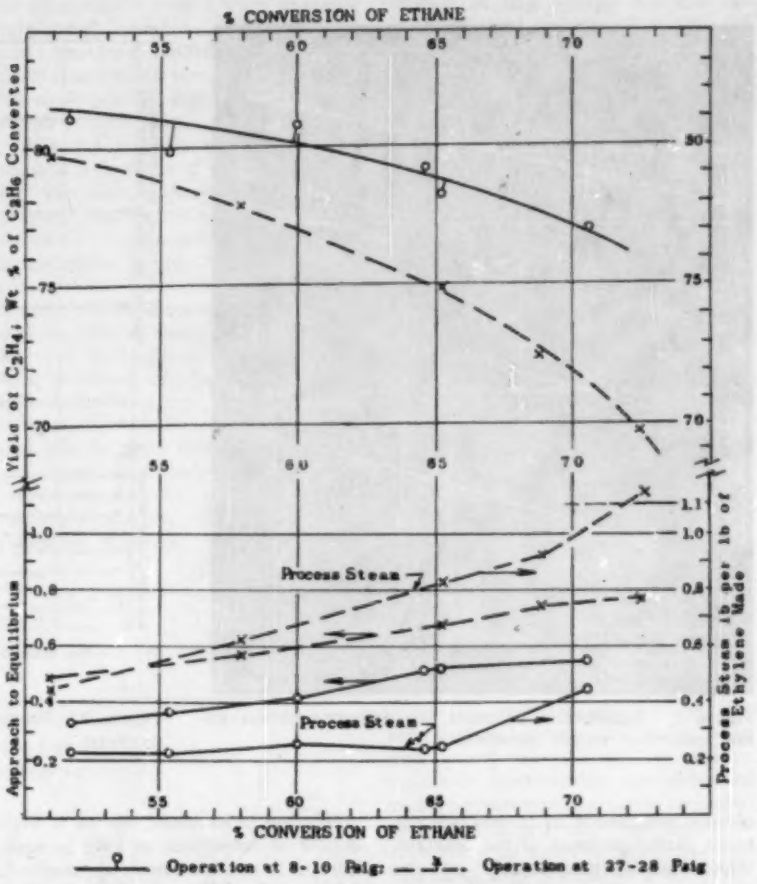
% CONVERSION OF ETHANE
Yield of C2H4; Wt % of C2H6 Converted
Approach to Equilibrium
Process Steam lb per lb of Ethylene Made
Process Steam
Process Steam
% CONVERSION OF ETHANE
Operation at 8-10 Psig: Operation at 27-28 Psig

Figure 3. Ethylene yield; process steam and equilibrium approach.

Reaction mechanism and reaction rates from operating data

When the formation of by-products and their variation with pressure, conversion, and equilibrium approach are considered, then it appears that the stoichiometric formula:

$$C_2H_6 \rightarrow C_2H_4 + H_2$$

is kinetically a highly improbable mechanism and that a chain of more elementary reactions is taking place. The transitory existence of free radicals and atoms in chemical conversions has been established by spectroscopic analysis. These radicals are in low concentration, not so much on account of any intrinsic lack of stability but rather due to their high reactivity, which results in their rapid disappearance by reactions with themselves or with other activated molecules present in the reactant mixture.

The definite and pronounced effect of the equilibrium approach in the over-all molecular mechanism

$$(C_2H_6 \rightleftarrows C_2H_4 + H_2)$$

on the product distribution, especially the methane formation, indicates that there are intermediate reactions involved which present an actual equilibrium barrier to the formation of C_2H_4.

Free-radical mechanisms for the thermal decomposition of organic compounds, including petroleum hydrocarbons, were proposed by Rice and his co-workers twenty-five years ago, and a specific chain of elementary reactions for the conversion of ethane was advanced in 1934 by Rice & Herzfeld *(9)*. This mechanism was modified in a later article *(10)*. The early work created a broad scientific interest in this field of kinetics resulting in an abundance of publications on the subject of free-radical reactions. Some experimental and theoretical investigations have resulted in an outright denial of the occurrence of such intermediate reactions or of the justifi-

cation for postulating them; other publications are of an affirmative nature as far as the free-radical concept is concerned, but propose modification of the mechanism originally advanced by Rice. The extensive literature on the subject is critically reviewed by Steacie in his classic ACS monograph on "Atomic and Free-Radical Reactions" *(14)*.

A study of Steacie's comments on the mechanisms proposed by various authors for the thermal conversion of ethane creates the impression that the occurrence of a chain of free-radical reactions is rather widely accepted, but the precise definition and sequence of steps still remain controversial. Experimental data on identification of free-radical species and their concentration are relatively scarce, and practically nonexistent in the high-temperature range, 1400 to 1600°F., encountered in commercial pyrolysis operations.

A kinetic study of a complex conversion mechanism should begin with the determination of the reaction rate and order of the over-all conversion, i.e., the disappearance of the original reactant—ethane in this case. Evaluations of the time-temperature factor have been made for the commercial operations and the equivalent residence time related to the coil-outlet temperature has been derived by a method previously described *(13)*. The apparent reaction rate is then determined, based on defining the conversion in terms of ethane disappearance and postulating a reaction of first order as defined by

$$\frac{dc}{dt} = k_r c \quad \text{or} \quad \ln \frac{c_o}{c_t} = k_r t$$

where k_r is the reaction rate in sec.$^{-1}$; c_o designates the moles of ethane in the original reactant; and c_t the moles of ethane remaining after time, t.

The reaction rates thus determined from the commercial operating data given in Tables 1 and 2, are shown on Figure 5. When taking into consideration reaction rates derivable from the experimental test data at 1400 and 1500°F. given in the paper of Kinney and Crowley *(4)*, and also the reaction rates determined by Hepp, *et al. (1)* from ethane pyrolysis tests at the 1800°F. level, the reaction rate vs. temperature relationship seems firmly established for the relatively high-temperature range encountered in commercial practice. Most of the earlier kinetic studies apply to conversions within a temperature range of 1050 to 1300°F. and the extrapolation of these correlations into the higher temperature region has led to considerable design errors.

The reaction rate relationship thus established can be mathematically expressed in the form of the well-known Arrhenius equation:

$$k_r = A\, e^{-\frac{E}{RT}}$$

where E is the activation energy and A an integration constant commonly termed "frequency factor." The correlation on Figure 5 is then represented by:

$$k_r = 1.535 \times 10^{14}\, e^{-\frac{70{,}200}{RT}}$$

which is in close agreement with equations derived by Sachsse *(11)*, Snow *(12)*, and Steacie and Shane *(15)*. The numerical value of the constant A is usually accepted as an indication of the reaction order. For first-order reactions most values of A are found to be within the range of 10^{13} to 10^{15}. Thus the above actual value of 1.535×10^{14} and the fact that a first-order reaction was postulated in developing the rate from the time-temperature factor for the individual runs, constitute reasonable evidence that the over-all conversion is of first order and controlled by the primary decomposition reaction.

If a second-order reaction had been postulated in deriving the rates from the commercial conversion data, the Arrhenius equation would take the following form:

$$k_r = 2.57 \times 10^{24} \times e^{-\frac{108{,}600}{RT}}$$

where k_r is in liters/mole/sec. since the rate for bimolecular reactions depends on the concentration. The absurdity of this equation is obvious.

Ethane is seemingly not re-formed in a chain of free-radical mechanisms which may occur and explain the formation of methane and other by-products.

The initial step in ethane cracking at temperatures in the order of 1500°F. involves the severance of the

continued on next page

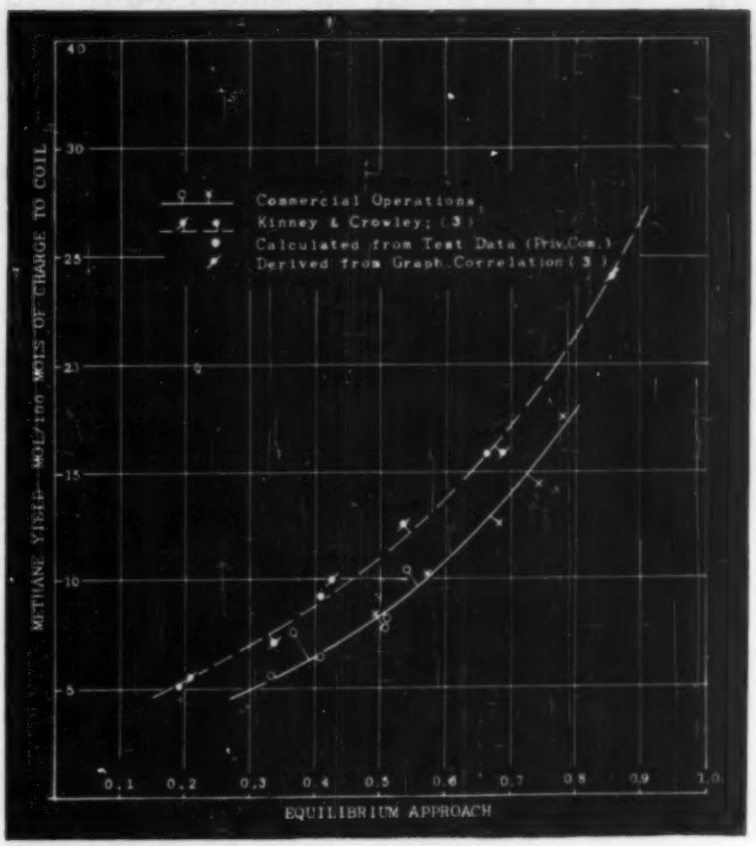

Figure 4. Methane yield vs. equilibrium approach.

Pyrolysis

continued

carbon-carbon bond and a hydrogen-carbon bond. Hinshelwood *(2)*, in his recent presidential address to the Royal Society, pointed out that "hydrocarbon pyrolysis involves the simultaneous rupture of a C-C bond and a C-H bond." The activation energy which, from the evaluated Arrhenius equation, appears to be 70,200 cal./mole, need not be in the order of the bond dissociation energies, as it also depends on the mode of excitation or the oscillation pattern of the whole molecule. This difference between bond and activation energy is quite general in thermal decomposition reactions of organic compounds, and in ethane cracking it seems to increase with temperature, which may explain why early investigators such as Marek and McCluer *(7)* have found a higher activation energy based on experimental tests in a lower temperature range.

Methane, no doubt, is formed by reactions involving free radicals and atomic or molecular hydrogen produced in the initial cracking step. The observed effect of equilibrium approach on the rate of methane formation and also on the formation of C_2H_6 and higher molecular weight fractions seems to point to such intermediate reactions as: $CH_3 + H_2 \rightarrow CH_4$ and $n\ (CH_2) \rightarrow C_n H_{2n} \rightarrow C_nH_{2n-x} + \frac{x}{2} H_2$, which become more pronounced when the formation of C_2H_4 from methylene radicals encounters equilibrium hindrance. Data studied by Travers and Silcocks *(16)* offer similar evidence of the equilibrium hindrance effect on the methane and polymer formation, and permit certain deductions as to the intermediate reaction mechanisms involved.

In summary of the above reflections on reaction mechanisms and kinetic aspects, it appears that a chain of elementary reactions in full explanation of the conversion mechanism involved in the pyrolysis of ethane at temperatures in the order of 1500°F., would differ appreciably from the system proposed by Rice and co-workers: 1) in the primary decomposition mechanism, 2) in the presence of methylene radicals, and 3) in the exclusion of an intermediate reaction of free radicals by which ethane is reformed. The proposal of a complete chain of mechanisms and the justification of each step based on thermodynamic (equilibrium) and kinetic (rate) consideration, is not presented at this time, as the evaluation of pertinent published information and new research data has not been completed. Such a study would also be too extensive for inclusion in this article.

Presented at A.I.Ch.E. meeting, Salt Lake City, Utah.

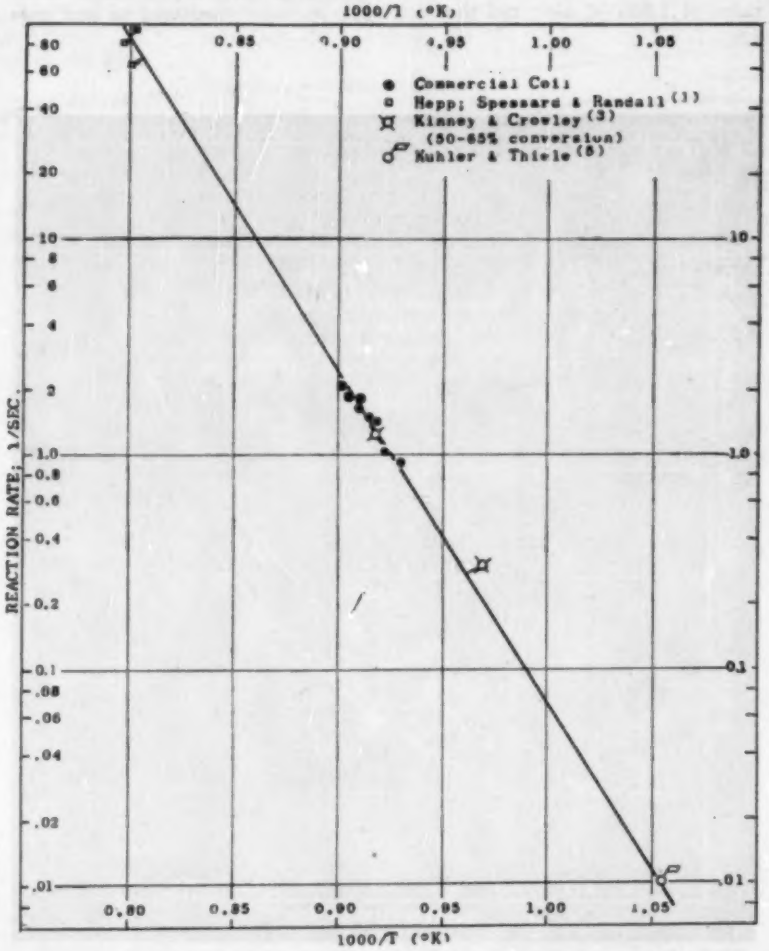

Figure 5. Reaction rate vs. temperature in thermal decomposition of ethane.

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Correction

In the article "Boiling Burnout with Water in Vortex Flow" by W. R. Gambill and N. D. Greene (C.E.P., October, 1958, p. 68) the following corrections should be made.

1. Page 69, second line from bottom of third column—"at" should be "as."
2. Page 70, lines 14 and 15 from bottom of second column—3680 should be 368; 355 × 10^9 should be 355 × 10^8.
3. Page 71, Eq. (8), $(\Delta_{t\ sub})_{exit}$ should read $(\Delta t_{sub})_{exit}$.

Analysis of rotary precoat filter operation New concepts—Part 2

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Efficiency Calculations. In line with the procedure set up in Figure 13, Figure 14 was equipped with a center calculation line and lettered similarly. In accordance with the previous reasoning, then:

$$\text{rate efficiency achieved, \%} = \frac{no}{mo} \times 100 \quad (8)$$

$$\text{efficiency loss due to blinding, \%} = \frac{rn}{mo} \times 100 \quad (9)$$

$$\text{efficiency loss due to penetration, \%} = \frac{mr}{mo} \times 100 \quad (10)$$

Realizing that with most slurries there is some residual flow, *even when the knife advance is stopped*, a better insight toward the real efficiency of the filter aid being used may be obtained by making a correction for what we have called *blind permeability* (see previous section on Analysis of the Filtering Cycle and Figure 10). Since filtrate is still being produced at the blind permeability rate while the cake is completely slimed over, the product of the blind fraction $\frac{rn}{mo}$ and the blind permeability constant, k, represents the portion of the achieved rate, no, due to blind flow. Having made this correction, effectively making the loss due to blind area larger, and the achieved rate smaller, further corrections would be required to determine the higher order effects. It has been determined that corrections to second order are generally sufficient. Equation (11) shows the simplified second-order calculation based on Figure 14.

$$\Delta Q_2 = nn' = \left(\frac{rn}{mo}\right) + k \left[\frac{k\left(\frac{rn}{mo}\right)}{mo}\right] + \cdots\cdots = \left(\frac{k}{mo}\right) rn + \left(\frac{k}{mo}\right)^2 rn + \cdots\cdots \quad (11)$$

Corrected average filtration rate for the cycle is represented by n'o.

Rate Times Yield. In any consideration of the economic aspects of a filtration process, both the rate and the yield must be considered in proper perspective. The relative importance of rate and yield, however, must be determined for each operation. When maximum production of a high-priced product is desired, the rate is of utmost importance while the cost of filter aid, and hence the yield, may be relatively insignificant. In operations such as waste disposal, a better balance between rate and yield must be maintained. In any case, the relative importance of the two factors should be determined, and this balance considered in establishing optimum economic operating conditions. Thus:

$$\text{economic optimum (EO)} = aQ \times bY \quad (12)$$

Where Q is rate, Y is yield, and a and b are constants which depend on the relative importance of rate and yield in a particular operation. For purposes of this discussion we shall consider rate and yield of equal importance in which case a and b will have values of unity.

Screening runs. Much preliminary information can be derived from cycles in which cuts at several different knife-advance rates are taken. Such information is inadequate, because the effect of penetration cannot be fully evaluated on anything except a full run at a single cut. Figure 15 shows the flow rate vs. knife-advance plots when filtering bentonite slurry with the grades of Celite filter aids for which permeabilities are given in Table 1 (see Part 1). Note that less permeable filter aids have a definite advantage over the "faster" filter aids at cuts below 3 mils. This advantage is emphasized in Figure 16, which shows yield in gallons of filtrate per

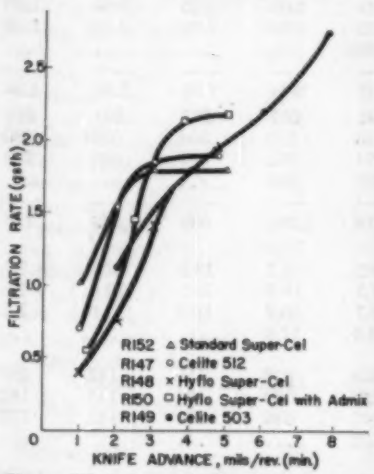
FILTRATION RATE (gal/ft)
KNIFE ADVANCE, mils/rev. (min.)
RI52 △ Standard Super-Cel
RI47 ○ Celite 512
RI48 × Hyflo Super-Cel
RI50 □ Hyflo Super-Cel with Admix
RI49 • Celite 503

Figure 15. Rate vs. knife advance comparison of several Celite filter aid grades filtering 2% bentonite slurry at 1 rev./min.

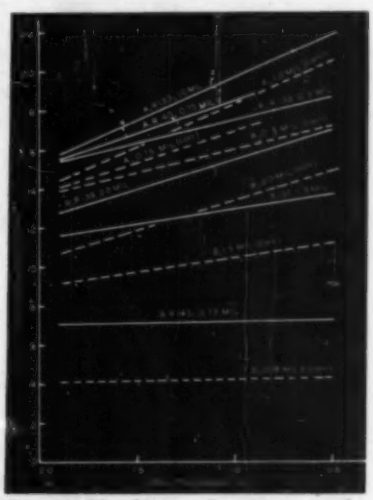

Figure 20. Observed rate vs. cake thickness filter aids A and B knife advance, mils/rev. (min.)

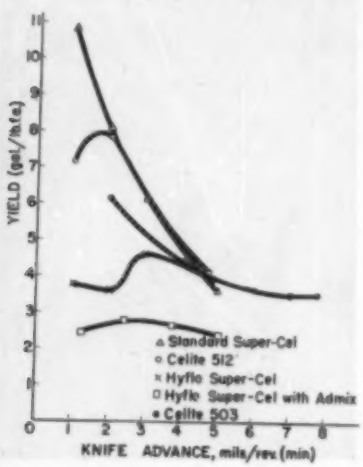

Figure 16. Yield vs. knife advance comparison of several Celite filter aid grades filtering 2% bentonite slurry at 1 rev./min.

pound of filter aid consumed, and is a result of the absence of penetration into the finer materials. Figure 17 is the rate-times-yield plot. Here again the finer materials show up best. An important point, however, is that the finest, Standard Super-Cel, has such a low permeability that it is impractical to apply a 2-in. cake on the vacuum rotary precoat filter, but it is conceivable that with slurries of finer particle size than bentonite, it may be advantageous to use the Standard Super-Cel, even with a 1-in. cake limitation.

In Figures 15, 16, and 17, note the relative positions taken by the other two filter aids under test. Although Hyflo Super-Cel is between Celite 512 and Celite 503 in permeability, Celite 503 takes the intermediate position in rate and yield performance. This may be explained as follows: the retentivity of Hyflo is just on the borderline for bentonite, and although almost 100% of the bentonite was retained on the Hyflo Super-Cel, enough passed through the Celite 503 to give the latter a rate and yield advantage. This is offset by sharply inferior clarification and would ultimately be reflected in reduced rate due to penetration. This illustrates the potential danger from the use of partial runs in an evaluation.

The two Hyflo Super-Cel runs are of interest. Figure 15 shows that in the run with admix a greater rate was achieved. Figures 16 and 17, however, point out that the admix did not improve the rate in proportion to the amount of extra filter aid used. Objectives are important too. If Figures 15, 16, and 17 were from an operation in which the product was extremely valuable and the cost of filter aid relatively insignificant, the Hyflo Super-Cel with admix would be the choice. If the slightly poorer clarity produced with Celite 503 could be tolerated, then its use at a heavy cut might be better. If clarity were most important, Celite 512 at about 3-mils cut would be the choice. If the filtration were one in which costs were to be kept at a minimum, a better balance between rate and yield would be necessary, and Standard Super-Cel at 2-mils cut would be the proper starting point.

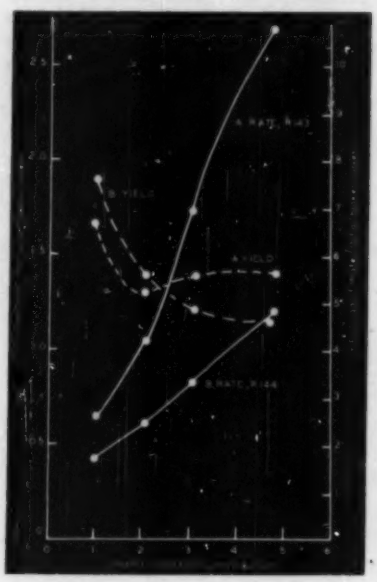

Figure 18. Rate and yield vs. knife advance, filter aid A vs. filter aid B, filtering 2% bentonite slurry at 1 rev./min.

Comparison runs. To illustrate differences which may be brought out between two filter aids of different type, but similar permeabilities, consider the following data on filter aid A having a permeability of 2.05 Darcies, and filter aid B, having a permeability of 2.33 Darcies.

Figures 18 and 19 show the results of single runs at several knife-advance rates with bentonite slurry. Filter aid A shows much higher rates than filter aid B as the cut thickness is increased. Filter aid A allows less penetration and thus "opens up" more rapidly as the cut thickness is increased. Regardless of the filter aid used, the rate will fall to practically zero with zero cut because of the extremely low filterability of bentonite slurry. The yield plot shows how the two filter aids trade places as the rates fall to

Table 2. Filtration of 0.5% Al(OH)$_3$ slurry on 5.38 sq. ft. rotary vacuum precoat filter. Conditions: 15 in. Hg vacuum, 60 sec./rev. 45% submergence

	Filter Aid A			Filter Aid B		
1—Run	133	140	138	139	137	145
2—Knife advance (mils/min.)	1.016	0.755	0.499	2.083	1.534	0.740
	0.940	0.754	0.500	2.049	1.510	0.735
	1.017	0.771	0.499	2.066	1.520	0.767
	1.024	0.764	0.495	...	...	...
Avg. or total	0.995	0.760	0.499	2.066	1.521	0.746
3—Knife travel (in.)	.370	.375	.250	.500	.500	.300
	.400	.375	.250	.500	.500	.300
	.400	.375	.250	.500	.500	.280
	.250	.075	.050	...	...	...
Avg. or total	1.420	1.200	.800	1.500	1.500	.880
4—Elapsed time (min.)	364	497	501	240	326	406
	426	498	500	244	331	409
	393	486	501	242	329	365
	244	98	101	...	...	...
Avg. or total	1,427	1,579	1,603	726	986	1,180
5—Filter aid wt. (lb.)	3.68	3.24	2.17	2.56	2.49	1.38
	3.64	3.41	2.03	2.65	2.64	1.46
	3.58	3.32	2.24	2.69	2.73	1.39
	2.32	0.65	...	...	...	...
Avg. or total	13.22	10.62	6.44	7.90	7.86	4.23
6—Filtrate (gal.)	412	692	667	277	331	231
	537	740	722	334	359	259
	680	771	672	347	369	236
	423	173	140	...	...	...
Avg. or total	2,052	2,376	2,201	958	1,059	726
7—Observed rate* (gal.sq.ft.hr.)	16.8	16.2	15.7	13.6	12.1	7.1
	18.5	17.5	16.3	15.1	12.9	7.2
	20.3	18.7	16.9	16.6	13.6	7.2
	21.7	19.4	17.3	...	...	...
8—Observed yield* (gal./lb.F.A.)	145	223	326	115	142	185
	194	229	360	124	145	182
	200	247	339	134	147	175
	206	262	...	...	...	...
9—Observed rate X yield*	2,436	3,613	5,118	1,564	1,718	1,314
	3,589	4,008	5,868	1,872	1,871	1,310
	4,060	4,619	5,729	2,224	1,999	1,260
	4,470	5,083	...	...	...	...

low levels because of low rate of knife advance. Since filter aid B is a bulky material, it has an illusory advantage when the cut is reduced to the point where both filter aid cakes are practically blind and flow rate is insignificant. Since the yield values are all fairly close, the rate times yield plots reemphasize the superiority of filter aid A.

A more extensive study with these same two filter aids using aluminum hydrate slurry included screening runs, and six complete runs using a single knife-advance rate for each. Table 2 shows complete observed and calculated data for the latter series of runs. Figure 20 shows the rate vs. cake thickness control plots. As noted in Table 2, line 7, observed data have been corrected to constant filterability by the following method: an Oliver 0.1-sq. ft. test leaf, with a wetted 11-cm. circle of Schleicher and Schuell No. 402 filter paper at 15-in. vacuum, was immersed for exactly 60 sec. and the total volume of filtrate measured in milliliters. The usual volume collected for the aluminum hydrate slurry was 150 ml., but varied from batch to batch and often within a given batch.

Hourly measurements were made. If the filterability were off the 150-ml. standard, the observed rate was corrected by this relationship:

$$\text{corrected rate} = \text{observed rate} \times \frac{150}{\text{filtrate volume (ml.)}} \quad (13)$$

This single correction removed irregularities resulting from changes in filterability. When the observed rate had to be corrected for filterability fluctuations, the observed yield was likewise corrected:

$$\text{corrected yield} = \frac{\text{corrected rate}}{\text{observed rate}} \times (\text{observed yield}) \quad (14)$$

Rate efficiency calculations were made from observed data (line 7) according to the principles set forth earlier. Note that filter aid A is far

continued

continued

Run	Filter Aid A			Filter Aid B		
	133	140	138	139	137	145
10—Precoat density (lb./cu.ft.)	22.2	19.3	19.4	11.4	11.1	10.3
	20.3	20.3	18.1	11.8	11.8	10.9
	20.0	19.8	20.0	12.0	12.2	11.1
	20.7	19.3	...	...	...	...
Avg. or total	20.8	19.7	19.2	11.7	11.7	10.8
11—Wt. of 1.5 in. Precoat (lb.) Avg. or total	13.91	13.24	12.90	7.86	7.86	7.26
12—Average** rate (gal.sq.ft.hr.) Avg. or total	18.64	17.63	16.96	14.73	12.50	7.25
13—Time to cut 1.5 in.** (min.) Avg. or total	1,506	1,974	3,006	728	987	2,090
14—Filtrate from 1.5 in. cut** (gal.) Avg. or total	2,515	3,119	4,569	976	1,125	1,360
15—Average yield (gal./lb.F.A.) Avg. or total	181	236	354	124	143	187
16—Avg. rate X yield Avg. or total	3,374	4,160	6,004	1,827	1,788	1,356
17—Over-all rate efficiency % Avg. or total	42.2	40.4	38.3	30.0	24.0	14.5
18—Loss from surface blinding % Avg. or total	18.3	19.4	19.5	27.5	31.5	40.0
19—Loss from deep penetration % Avg. or total	39.5	40.2	42.3	42.5	44.5	45.5
20—Blind flow (gal.sq.ft.hr.) Avg. or total	1.39	1.48	1.48	2.06	2.36	2.99
21—Avg. rate corr. for blind flow (gal.sq.ft.hr.) Avg. or total	17.25	16.15	15.48	12.67	10.14	4.26
22—Yield corr. for blind flow (gal./lb.F.A.) Avg. or total	167	216	323	107	116	110
23—Corrected rate X yield Avg. or total	2,881	3,488	5,000	1,356	1,176	469

* Corrected to constant filterability.
** Graphic Average.

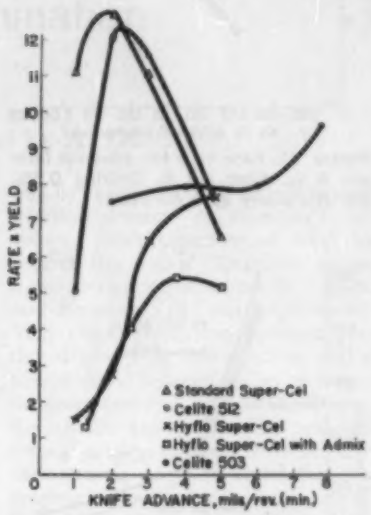

Figure 17. Rate times yield vs. knife advance comparison of several Celite filter aid grades filtering 2% bentonite slurry at 1 rev./min.

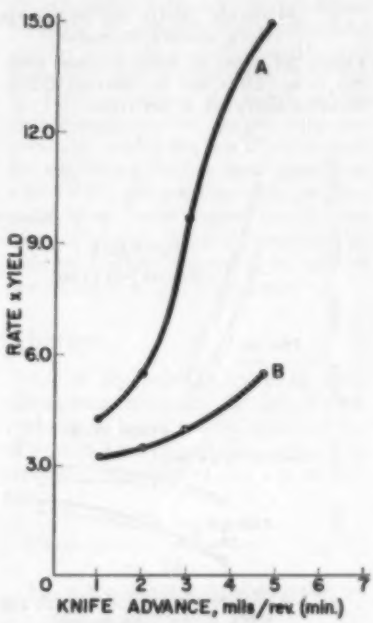

Figure 19. Rate times yield vs. knife advance, filter aid A vs. filter aid B, filtering 2% bentonite slurry at 1 rev./min.

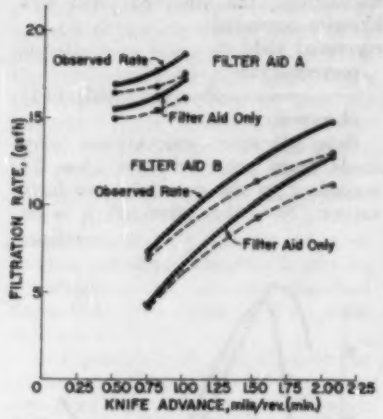

Figure 21. Rate vs. knife advance filter aid A vs. filter aid B, filtering 0.5% Al(OH)$_3$ slurry at 1 rev./min.

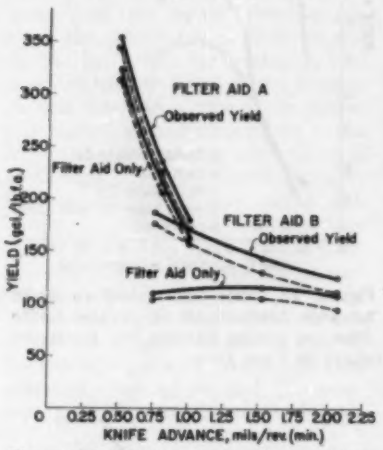

Figure 22. Yield vs. knife advance filter aid A vs. filter aid B, filtering 0.5% Al(OH)$_3$ slurry at 1 rev./min.

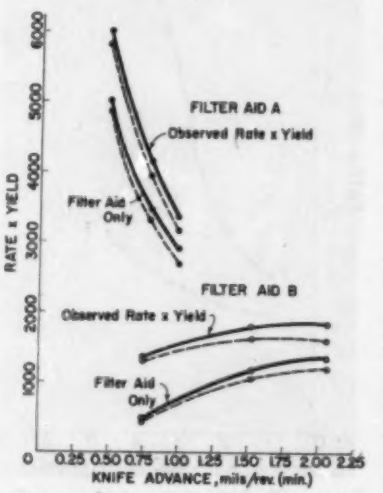

Figure 23. Rate times yield vs. knife advance filter aid A vs. filter aid B, filtering 0.5% Al(OH)$_3$ slurry at 1 rev./min.

continued

better than filter aid B in over-all rate efficiency, particularly at low cuts (line 17). This advantage is clearly shown to be primarily due to surface blinding. In deep penetration, filter aid A is still superior, although not as much so as in the other categories (lines 18 and 19).

Rate efficiency trends in both filter aids are toward higher efficiencies with heavier cuts, but rate times yield trends (line 16), are *in opposition to one another*. Filter aid A exhibits increasing rate times yield with decreasing cut while filter aid B shows a decrease. This takes on real significance when the duration of cycle (line 13) is considered. At 0.5-mil cut, filter aid A shows superiority over the 2-mil cut for filter aid B in *all* categories and the cycle length is over four times as long. The rate times yield trends indicate that further advantage might be forthcoming by a reduction in cut for filter aid A within the limitations of the equipment. Rate times yield performance of filter aid B is improved with *heavier* cuts but improvement appears to be such that the decreased cycle length would more than offset the rate times yield gain.

The solid curves from Figures 21, 22, and 23 show the observed and corrected rate, yield, and rate times yield values plotted vs. rate of knife advance. The broken lines represent the over-all rate when a turn-around time of 100 min. is assumed for each cycle. If cuts were indiscriminately heavy, the two filter aids would perform more nearly alike. Such filter operation would be neither desirable nor likely by an alert operator.

Order of magnitude of the over-all rate efficiency values is important. Since rate efficiency is essentially the percentage of theoretical capacity being utilized, it would be unwise to employ a filter aid at 5 percent of capacity. A switch to a finer, less penetrable filter aid at optimum cuts would result in improved rate and yield. Likewise, employing a filter aid at too high a rate efficiency would bring about poor economy because of the high ratio of precoat cake resistance to the total filtration resistance. Limits for most economical operation have not been established, but *the 40 to 60 percent rate efficiency range* would appear to be a good estimate. *If loss from surface blinding is heavy, a more rapid knife-advance rate is needed. If loss from deep penetration is excessive, the grade of filter aid should be changed for a more retentive one.*

Taking into account the permeability of a thin film of aluminum hydrate, a further analysis of the data can be made to approximate the performance of these same filter aids when filtering a slurry of otherwise similar characteristics but having no thin-film permeability. This represents true performance of the filter aids themselves. Corrections for flow through a film of Al(OH)$_3$ have been calculated in accordance with Equation (11) and are shown in Table 2, line 20. The solid curves from Figure 20 when corrected, as shown in broken lines, demonstrate the greater effect of blinding-film permeability under the conditions of greatest blinding. Rate, yield, and rate times yield are also shown corrected for thin-film permeability in lines 21, 22, and 23 and as the "filter aid only" curves of Figures 21, 22, and 23. Differences between the two filter aids are accentuated when the effect of the permeability of the Al(OH)$_3$ film is removed. This further increases the advantage of filter aid A over filter aid B.

Methods presented in this paper represent unique means for analyzing rotary precoat filter operations. The rate-times-yield concept affords the filter operator a mathematical means for utilizing both of these important factors, namely rate and yield in setting up optimum economic operating conditions. The method is flexible and should lend itself to almost any commercial rotary precoat filtering operation.

The more rigorous cycle analysis provides for a quantitative estimation of the relative amounts of deep penetration and surface blinding involved. These values may be used in guiding changes in the filtering operation to utilize the proper filter aid and achieve optimum rate times yield.

Complicated mathematical considerations have been avoided in an effort to present a down-to-earth, practical approach to the problem.

ACKNOWLEDGEMENTS

The authors wish to thank the Johns-Manville Corporation for permission to publish this paper. Thanks are also due Laurence E. Weymouth, Supervisor, and Jack Awde, Paul Balas, Joe Campbell, Dan DiBiasi, Jack Hillegass, Joe Rosi, John Sopoci, and Tony Wilczewski, who assisted in carrying out the experimental work in this program.

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Presented at A.I.Ch.E. Seattle Meeting.

Miniature Hydrocyclones—

energy requirements and solid elimination efficiency

Part 2—Solid elimination efficiency

D. E. Matschke and D. A. Dahlstrom

An equation is developed from experimental work to predict the value of solid elimination efficiency. Results predicted by this equation compare very closely with those by a similar equation developed earlier on large-diameter cyclones, even though the exponent values and the proportionality constants were slightly different in both determinations.

From experimental work reported in Part 1 on small glass hydrocyclones of 10, 20, 30, and 40 mm. with 10 degree included angle conical sections, the cyclone energy requirements at any particular capacity are given by a simple formula. Experimental results exhibited an average deviation of 4 to 5 percent. Feed volume split to the underflow appeared to account for most of this deviation. The equation is similar to that developed earlier for large diameter units with the exception of the proportionality constant. The somewhat higher value obtained in this study was felt to be due to the smaller included angle and the smoother glass surface. It is also emphasized that the equation assumes optimum cyclone geometry and ratios of feed and overflow diameter to cyclone diameter as discussed in the article.

Solid elimination efficiency was designated by the particle size reporting 50% by weight to both underflow and overflow streams. An equation is developed from experimental work to predict this value. Excellent agreement between experimental results and Equation (16) was experienced. Very close comparison between predicted results by this equation and a similar one developed earlier on large-diameter cyclones was obtained even though the exponent values and the proportionality constant were slightly different. It was also noted that for proper cyclone design with small diameter cyclones, the top particle size found in the overflow will be approximately twice that of the d_{50} value for similar specific gravities.

The miniature cyclones are capable of extremely high centrifugal forces resulting in significant concentrating actions even on particles in the one-to-three-micron range. For 2.74 sp. gr. solids in water, d_{50} values in the four-to-eight-micron range were experienced under the conditions tested. By employing higher feed pressures, which were not possible with the glass units, even lower values could have been obtained. Solid elimination can also be further improved by use of two or more stages of cyclones.

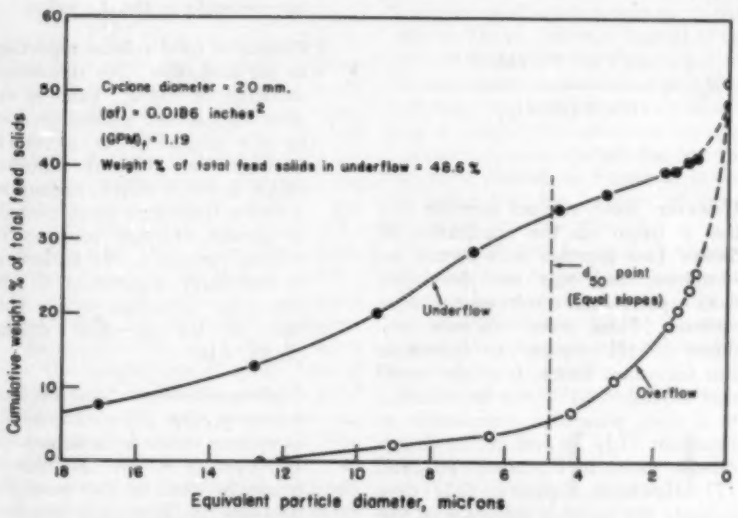

Figure 6. Typical results of hydrometer analysis.

Theory

All of the existing work on solid elimination efficiency in liquid-solid cyclones is based on the applicability of Stokes' Law to particle settling. In equation form Stokes' Law is as follows:

$$V_s = \frac{62.4\,(\rho_s - \rho)\,g\,d^2}{18\mu} \qquad (11)$$

Since the particle is undergoing an acceleration $\frac{V_t^2}{r}$ in the radial direction due to centrifugal force, it must eventually reach a position at which

continued

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continued

the resultant radial settling force of the particle equals the inward radial drag force due to the circulating fluid. Such a point for a given diameter particle is defined as the equilibrium radius.

The concept of the equilibrium radius was originally proposed by Driessen *(9)* and Criner *(4)*. Thus an equilibrium envelope can be established concentric with the cyclone axis for a given particle diameter. Superimposed on such a picture can be included the envelope of zero vertical velocity. Since this point defines the location of the inner radius of the free vortex and the outer radius of the forced vortex, it is argued that the zero vertical velocity corresponds to the equilibrium radius for the d_{50} or 50% particle size. This is the particle size at any solid specific gravity in equilibrium with the maximum centrifugal force generated and the radial drag force, and therefore, reports in equal amounts to the underflow and overflow streams.

The d_{50} point could serve as a good criterion of solid elimination efficiency if it can be related to the major factors which influence the generation of centrifugal force in a cyclone. In earlier work on larger cyclones, the following empirical correlation was developed *(5)*:

$$d_{50} = \frac{C\,(of)^{0.68}}{(\text{GPM})_f^{0.53}} \left[\frac{1.73}{\rho_s - \rho_0}\right]^{0.50} \quad (12)$$

It is interesting to note that in Kelsall's experimental work, the vertical, radial, and tangential velocities in a cyclone were measured at several throughput rates *(12)*. From these data, calculations were made, based on Stokes' Law, to determine the "envelope of equilibrium" for various micron particle sizes for the solid specific gravity involved. In addition, by measuring vertical velocity components, he was able to determine the "envelope of zero vertical velocity." This corresponded to the inner radius of the free vortex and the outer radius of the forced vortex. He therefore reasoned that the particle whose "envelope of equilibrium" was the same as the "envelope of zero vertical velocity" represented the d_{50} particle size. The d_{50} value calculated by Equation (12) compared within one micron of Kelsall's equilibrium particle diameter or d_{50} value. The excellent comparison between the theoretical development and the empirical equation emphasizes the desirability of employing the d_{50} point for correlation work with the miniature hydrocyclones.

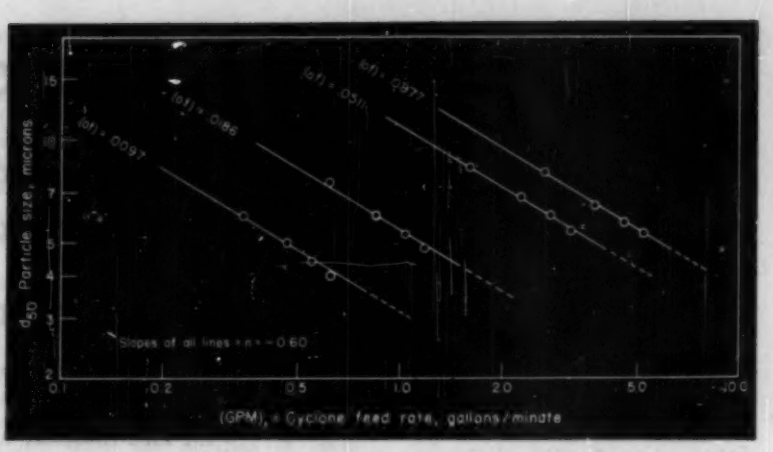

Figure 7. d_{50} point as a function of cyclone feed rate. Parameters of overflow X feed diameter, square inches.

It should also be emphasized that, until very recently, all the experimental correlations and work cited had been on 50% particle sizes of eight microns or larger. On first examination, there is no reason to believe that this relationship will not hold for d_{50} values well into the minus eight micron range. However, this approach is based on the adherence to Stokes' Law, and it is feasible that the higher centrifugal and shear forces involved in the smaller cyclones may not allow this assumption.

In recent work by Haas, *et al.*, the following equation was suggested for rough estimates of the d_{50} value for hydrocyclones less than 1-in. diam. *(11)*.

$$d_{50} = \frac{(5 \times 10^3)\,(D_\mu)^{0.50}}{(F)^{0.22}\,[62.4(\rho_s - \rho)]^{0.50}} \quad (13)$$

However, these authors indicate that this is based on the application of Stokes' Law together with certain assumptions and was not developed from experimental results on miniature cyclones. Thus, more concrete evidence is still required to determine this important factor. It is also noted that Equation (13) can be modified to a form somewhat comparable to Equation (12) by use of the design criteria given in Equations (6) and (7). However, Equation (13) does indicate the possible influence of viscosity which would be useful in predicting results with nonaqueous suspensions.

Other variables exist that might affect solid elimination efficiency. These, not included in the foregoing treatment, are as follows:

1. **Feed solids concentration.** All work on larger cyclones indicates no influence on d_{50} as long as feed solids concentration is below 10 to 12 vol. %. Above this value, "hindered settling" conditions cause increasing deviations *(4, 5, 7, 10, 17)*.

2. **Included angle of the conical section.** The d_{50} value increases with an increase in included angle *(5, 13, 17)*. In addition, sharpness of classification is reduced. With large cyclones, decrease in included angle below 10 to 15 degrees gave little if any decrease in the d_{50} value.

3. **Percent of total volume reporting to the underflow.** No significant influence on the d_{50} value is experienced as feed volume percent to the underflow is increased beyond the natural dilution effect. In other words, as long as a vortex underflow spray pattern is present, further increase in volume percent to the underflow is essentially equivalent to diluting the underflow with a portion of the overflow stream *(5, 10, 15)*.

4. **Cyclone diameter.** Most cyclone papers predict a decrease in d_{50} as cyclone diameter is decreased. However, it is felt that this is primarily due to the resulting decrease in inlet and overflow diameters consistent with proper

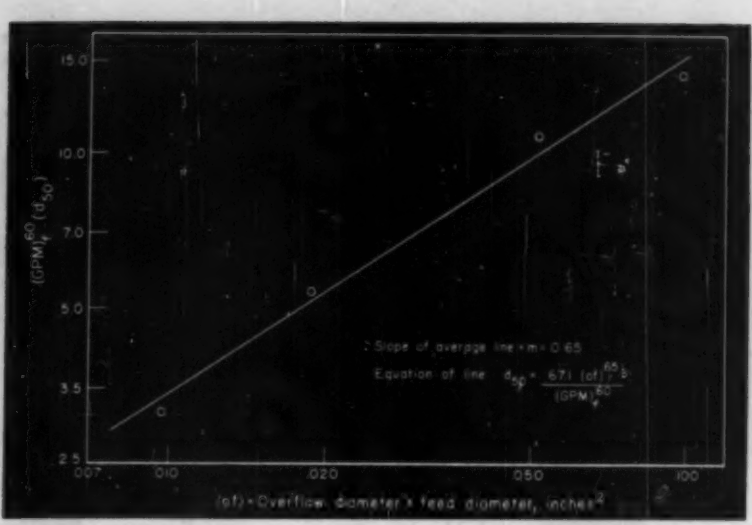

Figure 8. $(GPM)_f^{.60}$ (d_{50}) as a function of overflow X feed diameter.

nozzle to cyclone diameter ratios discussed earlier *(5, 11, 14, 17)*.

5. **Type of underflow discharge.** The necessity of the vortex-type discharge is emphasized in earlier work *(5)*. The "sausage" or overloaded discharge of Yancey and Geer results in severe losses in elimination efficiency *(17)*. Undoubtedly this is due to the loss of a high efficiency vortex flow pattern as energy requirements are also severely reduced *(5)*. However, this may be advantageous where maximum underflow solids concentration is important.

Experimental equipment and method

The equipment employed for this portion of the study was the same as previously given and shown in Figures 2 and 3 of Part 1. Runs were made and samples taken to determine solids content and size distribution in all streams. A dispersed clay of 2.74 sp. gr. was employed in all runs. No particles were present coarser than 30μ with 90% being finer than 13.5μ and 50% finer than 2μ equivalent diameter. Therefore, the bulk of particles fell within the critical classification region of the small cyclones employed.

To calculate the d_{50} value for each run, the weight rate of solids, one of the two factors, was measured by first timing the slurry volume rate for the underflow and overflow streams. The weight of solids in a unit volume of slurry was then determined by filtering and drying. The weight percentage of total feed solids reporting to each stream was then easily calculated.

The size distribution in each stream, the other factor required for d_{50} calculation, was obtained by the Casagrande hydrometer method previously reported *(2, 3, 5, 16)*.

The results of the analysis for a particular stream yields "weight % of total solids coarser than" as a function of particle equivalent diameter (diameter of a sphere which, having the same specific gravity as the particle in question, settles at the same terminal velocity).

The cumulative weight percent of total feed solids reporting to each stream is then plotted as a function of particle equivalent diameter on coordinate paper. These data are calculated merely by multiplying the respective size distribution by the weight % of total feed solids reporting to that stream. The d_{50} point is located at the particle diameter where the slopes for the two stream curves are equal. This indicates solid weight per particle size is increasing at the same rate for each stream. A typical analysis for one run has been plotted on Figure 6. It will be noted that the location of equal slopes for this case was 4.8μ.

Equation (12) for solid elimination efficiency was employed as a basis for the correlation of the data obtained on the small diameter cyclone, to ascertain if this approach was dependable in predicting d_{50} values.
This expression in general form is:

$$d_{50} = \frac{C(of)^m}{(\mathrm{GPM})_f^n} \left[\frac{1.73^{0.50}}{\rho_s - \rho_0} \right] \quad (14)$$

From the above, when d_{50} is plotted as a function of feed rate on log-log paper with parameters of (of) and constant ρ_s and ρ_0, the resulting curves should be straight lines with a slope of $(-n)$ and intercepts determined by the (of). Any major deviations of the data from such a plot will point up the inapplicability of previous investigators' work to the miniature hydrocyclones.

Continuing, a second log-log plot of $[(d_{50})\ (GMP)_f^n]$ as a function of (of) should yield a straight line with slope m and an intercept value involving a constant and a function of the specific-gravity difference between the solids and the overflow stream. If this plot is substantiated by data over the extended cyclone range, it will be a reasonable indication that equations at least comparable in form to those arrived at earlier can be utilized for solid elimination efficiency.

The effects of the other variables, mentioned in the literature review, were not examined by the authors but were optimized on the bases discussed previously.

Results and conclusions

Runs were made at four different (of) values, one from each of the four cyclones. The (of) values examined were 0.0097, 0.0186, 0.0511, and 0.0977 sq. in. Four different feed rates were taken for each of the four (of) values corresponding to feed pressures of approximately 5, 10, 15, and 20 lb./sq. in. gauge.

Figure 7 is a log-log plot of the d_{50} values in microns determined for each run as a function of cyclone feed rate in gallons per minute with parameters of (of) values. Average lines of slope -0.60 were drawn as this yielded the best fit. Excellent agreement of all data with the average lines drawn is readily apparent. Therefore, the assumption of $n=0.60$ in Equation (14) was felt to be entirely valid.

From the average lines of Figure 7, the value of $(d_{50})\ (\mathrm{GMP})_f^{0.60}$ was calculated for each parameter. Figure 8 is a log-log plot of $(d_{50})\ (\mathrm{GPM})_f^{0.60}$ as a function of (of) in square inches. Again, good agreement with an average straight line is apparent. The slope of the line of best fit is 0.65 which is the value of m in Equation (14). The equation of the straight line in Figure 8 is:

$$d_{50} = \frac{67.1\ (of)^{0.65}}{(\mathrm{GPM})_f^{0.60}} \quad (15)$$

If Stokes' Law can be assumed valid as proven with the larger diameter cyclones *(5)*, Equation (15) can be

continued

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continued

made more general by including particle specific gravity. In the experimental work, solids specific gravity was constant at 2.74. Overflow specific gravity varied within the range of 1.03 to 1.07 and an average value of 1.05 was assumed. Therefore, Equation (15) can be converted to the more general form as follows:

$$d_{50} = \frac{87.2\ (of)^{0.65}}{(\mathrm{GPM})_f^{0.60}} \left[\frac{1}{\rho_s - \rho_o}\right]^{0.50} \quad (16)$$

The proportionality constant $C=87.2$ is accordingly restricted to 10 degrees included angle cyclones with wall surfaces of smoothness equivalent to that of glass. In addition, a vortex underflow and major cyclone dimension proportions as discussed previously is assumed. Due to the excellent agreement experienced, it is felt that Equation (16) can be employed in closely predicting miniature hydrocyclone solid elimination efficiency.

It is interesting to compare predicted d_{50} results of Equation (16) with the approximation made by Haas, *et al.*, in Equation (13) and the earlier work on larger diameter cyclones given by Equation (12). In the latter case, the proportionality constant C was found to be equal to 81 for cyclone included angles of 20 degrees and cyclone diameters of 3 in. or greater. A typical case will be assumed as follows:

D = cyclone diameter = 10 mm. = 0.394 in.
o = overflow diameter = 2.5 mm. = 0.0985 in.
f = feed diameter = 2.0 mm. = 0.0787 in.
of = 0.00775 sq. in.
ρ_s = 3.0
ρ_o = 1.05
ρ = 1.0
μ = 0.8 centipoises
F = 50 ft.
$(\mathrm{GPM})_f$ = 0.616 gal./min., from Equation (10)

The predicted d_{50} value for the three equations is as follows:

Equation (12), $d_{50} = 3.64\ \mu$
Equation (13), $d_{50} = 2.45\ \mu$
Equation (16), $d_{50} = 3.55\ \mu$

While all results seem to compare quite closely in order of magnitude, there is actually a 31% deviation between Equation (13) and (16). As the former was not verified experimentally, the deviation is understandable. Equation (12), on the other hand, is only 2.5% different from Equation (16). As it represents an eight-fold extrapolation of the Equation with respect to cyclone diameter, the agreement is remarkably close. Comparison of the exponent values on $(\mathrm{GPM})_f$ and (of) for the two equations also indicates close agreement.

Another important consideration is the comparison of the coarsest particle found in the cyclone overflow with the d_{50} value. In all cases but the (of) parameter of 0.0097 sq. in., the overflow top particle size ranged from 1.8 to 2.0 times the d_{50} value. For the 0.0097 sq. in. (of) parameter, the range was 2.0 to 2.8 although only a small amount of coarser solids near the upper limit was present. As indicated earlier, the 10-mm. cyclone at the smallest (of) values deviated slightly from optimum design ratios. Thus, this deviation is probably due to the presence of "tramp" oversize and could have been eliminated by proper design. The ratio of top partice size in the overflow to the d_{50} value of 1.8 to 2.0 compares favorably with results achieved in larger diameter cyclones for "nonhindered settling" conditions.

It should also be emphasized that the application of small diameter cyclones could also involve staging of cyclones to improve total solids separation. For example, it might be desirable to recover or eliminate practically all solids finer than 3 μ. Thus, cyclone dimensions and pressure drop could be selected to yield a d_{50} value in that order of magnitude. This would still yield solids in the first stage overflow coarser than 3 μ. However, by recycling the overflow in a second stage, additional solids, both above and below 3 μ would be concentrated in the second-stage underflow. Obviously, this could be continued as long as economically feasible. This system is already being practiced in industrial applications.

NOTATION

a = exponent on F in Equation (8)
b = exponent on (of) in Equation (8)
C = proportionality constant in Equation (12) and (14)
d = particle effective diameter, ft.
d_{50} = equivalent diameter of particle reporting 50% by weight to both underflow and overflow streams, μ
D = cyclone I. D., in.
f = cyclone feed I. D., in.
F = applied head between feed and overflow nozzles, feet of fluid
g = effective acceleration, ft./(sec.)(sec.)
$(\mathrm{GPM})_f$ = feed volume flow rate, gal./min.
$(\mathrm{GPM})_f'$ = feed volume flow rate corrected for underflow solids slurry volume not entering into cyclone energy loss as per Equation (3), gal./min.
K = proportionality constant in Equations (3), (8), and (9)
K' = proportionality constant in Equation (1)
K'' = proportionality constant in Equation (2)
K''' = proportionality constant in Equation (4)
m = exponent on (of)
n = exponent on $(\mathrm{GPM})_f$
o = cyclone overflow diameter, in.
r = radius
V_t = tangential velocity
V_s = terminal settling velocity of particle, ft./sec.

Greek letters

a = exponent on radius involved in Equation (1)
ρ = specific gravity of fluid, g./cc.
ρ_o = specific gravity of overflow slurry, g./cc.
ρ_s = specific gravity of solid, g./cc.
μ = liquid viscosity, lb./ft.-sec.

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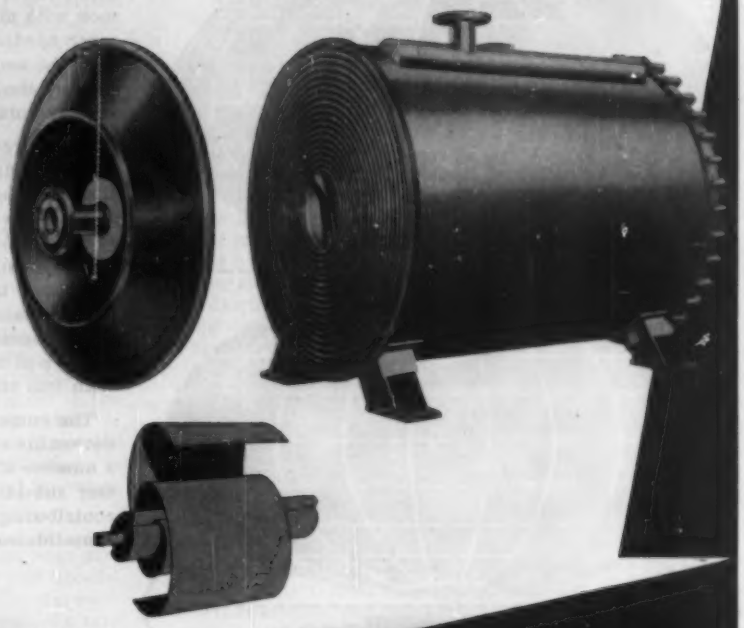

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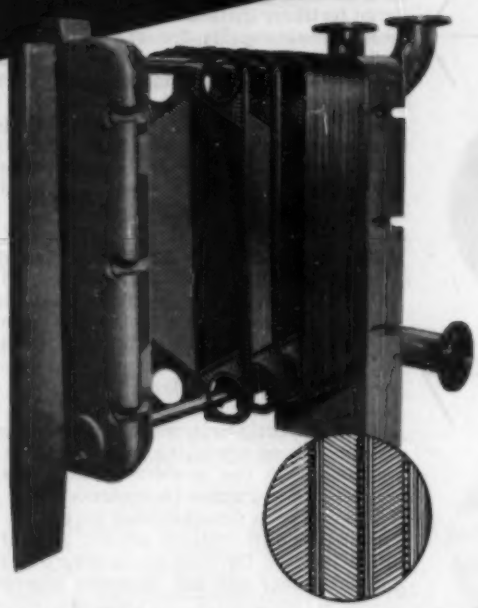

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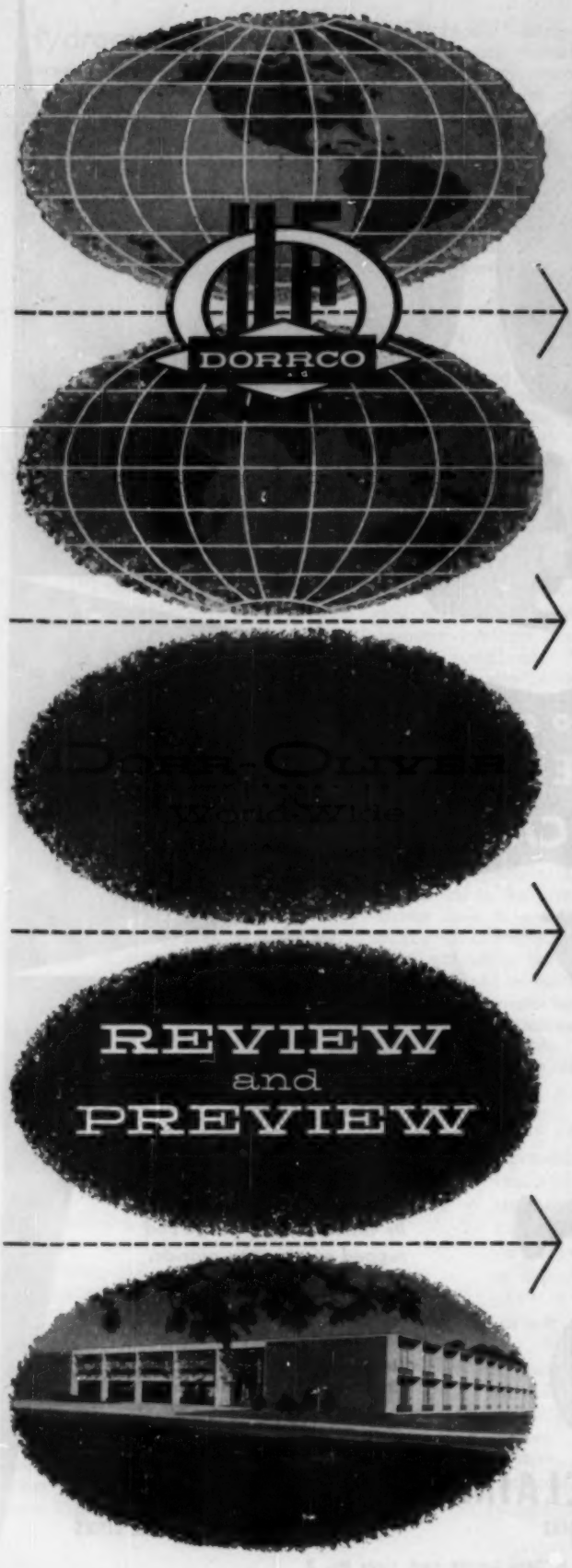

1958 has been a year of healthy consolidation. The generally lower level of new business we have had in common with most capital goods companies has given us a much needed opportunity to examine all our operations with the emphasis on sharpening efficiencies and stepping up the rate of our technological advance. In both, we have made substantial gains.

The sharpening of efficiencies is evidenced by a number of changes. Our manufacturing costs and delivery times are both noticeably better. A reorganization of our Research & Development group has resulted in a greater emphasis on basic research and a speeding up of development of new processes and equipment. This will ultimately include more and better manpower in both these areas. We have simplified routines, eliminated many nonessential operations and projects which seem to creep in during boom times. This allows us to proceed with less staff, but a more able and experienced one.

The current lag in new business has been much less noticeable overseas, and we have been concerned with a number of very large and significant projects abroad. Our subsidiaries have continued to progress and are contributing substantially to the financial balance of our consolidated effort.

PLANT ENGINEERING — The year's major project was the design of a 150 metric ton per day triple superphosphate plant for Mexico. This large contract includes process engineering, plant design, purchase of equipment and supervision of construction of the granular fertilizer plant as well as attendant facilities such as labs, cafeteria, offices and guest house.

A second substantial current project, which is being carried out jointly by D-O and one of our subsidiary companies in Europe, is the design of a large Yugoslavian copper concentrator. Also engineered abroad were a Belgian dicalcium phosphate plant and the expansion of a German phosphoric acid plant. During the year a large fertilizer installation in England went into operation and was rapidly brought up to operating capacity. A fertilizer plant in Montana and a copper concentrator in Israel, both D-O designed, were put into operation late in the year.

Latest addition to the list of installations which the company can now design is the board plant. We are staffed and equipped to engineer any of the basic types including wet or dry process hardboard and particle, insulating, gypsum and flake board.

PULP AND PAPER — A Canadian pulp producer will install a complete D-O Bleach Plant, and Bleach Washers will be utilized in expansion of an Indian groundwood mill. Late in the year Brownstock Washing and Recausticizing Systems, Deckers and hypochlorite preparation equipment were ordered for a new French mill. At a second French mill, a large Brownstock Washing System was put into operation in 1958.

Recausticizing Systems will be installed at two other new mills, one producing paper in India and the other linerboard in the western United States. Continued evidence of widespread acceptance of the American Disc Filter has been demonstrated by the number of orders entered for this efficient saveall. Also of interest were filters ordered for local manufacture from our Australian subsidiary and our Japanese representative.

FOOD PRODUCTS — In the citrus industry, Merco Centrifuges and Mercone Screening Centrifuges have been applied to the finish-processing of orange juice prior to concentration. Successful also has been application of

the Centrifuge-Precoat Filter combination to apple juice processing.

Corn starch washing systems consisting of various combinations of centrifugal equipment were ordered for mills in the United States, Colombia, Holland and Mexico. And, as in so many previous years, the sale of RapiDorr Clarifiers and O-C Filters for cane sugar processing has contributed heavily to orders entered.

FLUOSOLIDS SYSTEMS — Applications of the FluoSolids system were broadened in 1958 to include heat treatment or drying of such materials as foundry sand, phosphate base food products and concentrated detergent and for carbon reactivation. Another new application will be partial roasting of sulfide concentrates at one of Canada's largest smelters.

Other FluoSolids projects now in the design stage or under construction are slag dryers for India and Alabama; pyrite roasters for Spain, South Africa and California; a coal dryer for a midwestern producer and two-stage arseno pyrite roasters for installation in the gold fields of northern Canada. Now in operation or under construction around the free world are over 100 FluoSolids installations on such proven applications as sulfide ore roasting, coal and slag drying, and limestone and phosphate rock calcination.

SANITATION — This phase of our business has been particularly active during 1958 both at home and abroad. Over thirty-five installations of the CompleTreator sewage treatment unit, first introduced last year, are now in operation providing treatment facilities for housing developments, industrial plants, and other small centers of population. Equipment for large domestic projects now under construction include Clariflocculators for a chemical precipitation plant in northern New York State, Densludge Thickeners for the nation's capitol, large Digesters and Distributors for Dallas County, and Clarifiers and Distributors for a Biofiltration plant in Kansas.

Abroad, D-O will supply units for two plants in New Delhi, as well as for installations in Venezuela, Iraq and Kenya. North of the border, extensive additions to the metropolitan Toronto treatment system will be D-O equipped.

Major developments in this field have been the SR Clarifier, a new rapid sludge removal mechanism for final clarification in biological treatment, and the D-O Aerator for the activated sludge process. Installations using both units are already in operation, and a major pulp and paper producer has ordered Aerators for a new waste treatment plant.

COAL — Fine coal recovery and water clarification will be accomplished at Eastern and Australian cleaning plants in large Thickeners ordered within the past year. In a number of instances, an American Filter and ODS Pump will complete the fines recovery circuit.

IRON AND STEEL — Proof of the versatility of the DSM Screen is its application at three points in the heavy media cyclone flowsheet. In its first use on the Iron Range it has considerably reduced magnetite losses. In this general field also the Thickener-Filter combination has continued to be widely applied to recovery of blast furnace flue dust.

CHEMICAL — In 1958 new developments highlighted Dorr-Oliver activity in the far-flung chemical industry. Among the foremost of these was the plastic Filter, a rotary drum vacuum unit constructed of plastic with glass fiber reinforcing. Initial orders indicate the applicability and economy of this unit for mildly corrosive applications.

A second major development, the Merco H-30 Centrifuge, provides the chemical industry with a high capacity, high speed unit capable of clarifying up to 600 gallons of slurry per minute. The product of nearly four years of testing, this machine has substantially reduced operating power requirements per gallon of feed. One of the first commercial applications will be crystal separation at 90° below zero.

Result of yet another new design program is the expanded line of Type L centrifugal pumps. Here, three new designs provide increased capacity and head range and reverse inlet flow for operating speeds of both 1750 and 3500 rpm. In addition, Hypalon elastomer lining is now standard for both Olivite and ODS Pumps.

During the year a German manufacturer ordered the eighth and ninth Horizontal Filters for dewatering artificial resins, and domestic producers purchased Horizontals for such applications as washing ammonium sulfate and nitrocellulose and filtering potash and copperas. Also in the potash field was use of the DSM Screen for debrining crystallizer underflow.

GENERAL METALLURGICAL — Development of an air-lift agitation system for the American Filter has provided a third method of maintaining heavy solids in suspension prior to filtration. Complementing the conventional paddle and swing agitators, this new method has been extensively tested at operating installations.

U. S. and Chilean producers have ordered giant Thickeners with the strongest turntables ever fabricated, and a copper mill in the Belgian Congo will utilize ten large vacuum Filters in a current expansion. New construction at U. S. cement plants includes the three largest Slurry Mixers ever furnished, each 120 feet in diameter, as well as a variety of smaller machines.

WATER — Here also new construction and plant expansions resulted in application of a variety of D-O pretreatment equipment. Two large Hydro-Treator mechanisms will supplement four additional units already in operation at Miami, Florida; and Topeka, Kansas will utilize Presedimentation Clarifiers and Flocculators. PeriFilter systems will be installed at Peoria, Illinois and Leander, Texas; and in Mexico City the first PeriFilter of a new, simplified control design is now going into operation.

Not the least of our gains in efficiency has resulted from new and vastly improved headquarters facilities both here and abroad. Our new International Headquarters was completed here in Stamford in July, the staff of D-O NV expects to move its own new office building in Amsterdam shortly, and our associates in both Brussels and Paris are enjoying new and excellent facilities in co-operatively owned buildings.

In every respect, we are better prepared than ever before to take advantage of the upswing to come and to give better service to our customers throughout the world. This betterment, of course, could only have come about by the diligent and co-operative efforts of our total staff, and to them belongs the credit for the work done.

J. D. Hitch, Jr.
President

November 5, 1958

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Mercone, CompleTreator and ODS are trademarks of Dorr-Oliver Hypalon—Reg. T.M. E. I. du Pont de Nemours & Co.

For more information, turn to Data Service card, circle No. 16

New computer program to save CPI companies major dollar outlays

A new computer interchange plan, sponsored by A.I.Ch.E., will save process operating companies major expenditures, will avoid duplication of effort.

Chemical processing firms making developmental or operational use of large computers stand to benefit from action just approved by A.I.Ch.E.'s highest governing body, its Council. As a result of this action, detailed programs outlining the stepwise organization and machine solution of chemical engineering problems, some complete with card decks and reels of tape (precoded for instructing a given computer), will be issued by the A.I.Ch.E. The Institute will function as a central collecting point and publishing organization.

A number of major chemical and petroleum refining firms, who have completed development of several such programs, have specifically agreed to release certain of these programs as a basis for getting the plan underway. Some of these programs have cost thousands of dollars to develop, will help avoid duplication of effort and unnecessary expenditures of such large sums.

The A.I.Ch.E. action, which took place at the Cincinnati Annual Meeting, consisted of two interrelated steps:

1) Formation of a new Committee of the Institute known as the Machine Computation Committee.

2) Plans for publication of computer abstract programs in CEP, and publication of complete manuals for computer programs contributed by the companies or schools which developed them.

Excellent progress has been made in the interchange of computer coding techniques and mathematical procedures through the extensive cooperative efforts of agencies such as the "Share" organization, which was created by users of the IBM-704 computer. But virtually no interchange exists for computer programs which have direct use to chemical engineers.

Ad Hoc Committee

At the time of the A.I.Ch.E. Golden Jubilee Meeting in Philadelphia (June 23-27, 1958), the Council authorized an "ad hoc" committee to study this problem area and to report to them with further information for definitive proposals. W. M. Carlson of du Pont was named chairman and instructed to form his committee. The names of the committee members* show that the viewpoint of the chemical companies, the oil companies, the contractors, and the universities were all represented on this "ad hoc" committee which was dissolved in December.

The Committee gathered and considered much information during its relatively short existence:

1) It verified that there are no general cooperative computer users' organizations that effectively serve the process industries. In general, existing groups are computer-oriented rather than industry-oriented.
2) It verified by questionnaires and by direct contact that more than sufficient interest and implied support, in terms of personnel and programs, could be expected from the process industries to justify the program.
3) It verified that no legal barriers exist to such "company-to-company" and "company-to-institute" cooperation as is being considered.
4) It estimated that the program can be made essentially self-supporting from the beginning with sufficient industry cooperation, and can eventually either return a small profit to the Institute or become a self-supporting integral part of the Institute without the need of industry support.
5) It verified by direct contact that other A.I.Ch.E. committees are not working in this field and that a need exists for a new, permanent committee on machine computation.

The Committee then recommended that only two levels of service be attempted at first. One is the publication in CEP on a continuing basis of a large number of abstracts of programs which their originators are willing to make available. The selection for publication and the control of format of these abstracts would be the responsibility of the Machine Computation Committee.

A sample abstract is shown. Abstracts should be submitted to the Machine Computation Committee, c/o A.I.Ch.E., 25 W. 45th Street, New York 36, New York.

The second level of service will be that of issuing complete program manuals of large, general-purpose programs. These manuals will be published and distributed by the A.I.Ch.E. at a cost of from $20 to $60 per manual.

Tentative standards for preparing and issuing the manuals is shown. It is expected that at least five such general-purpose manuals can be made available from the Institute in 1959,

continued on page 88

Sample Computer Program Abstract

ORIGIN: Typical Chemical Company
Department of Automatic Computation
Programmed by H.E.L. Pless

TITLE: Equilibrium Flash Vaporization

DESCRIPTION: This program calculates isothermal equilibrium flash vaporizations where the feed composition and K values are specified. The program uses conventional isothermal equilibrium flash calculation equations and will handle up to 40 components. Programmed floating point arithmetic is used.

COMPUTER: IBM 650 or Datatron 205

PROGRAM LANGUAGE: IT (Internal Translator)

RUNNING TIME: 2 to 8 minutes per case depending on the number of components.

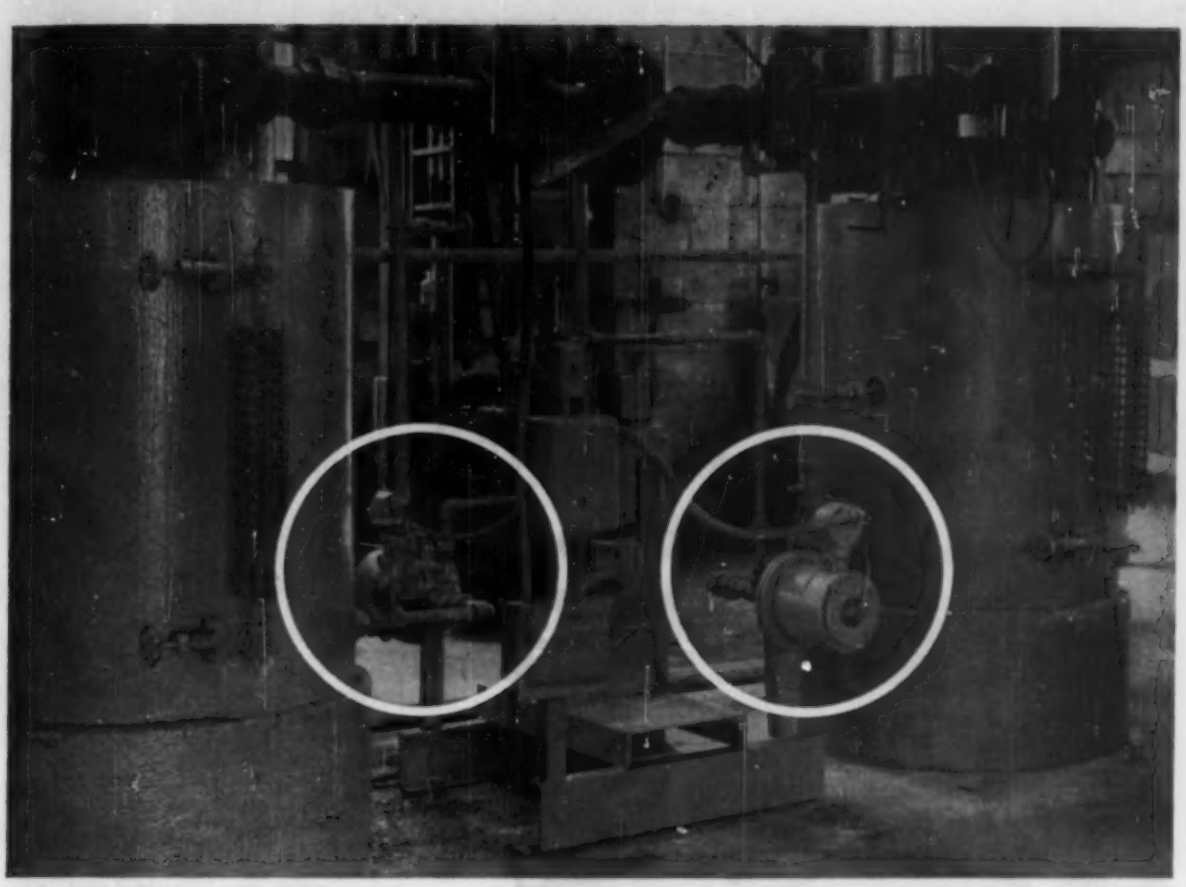
COMMENTS: Program checks that the sum of the mole fractions of the feed is equal to one and that the system is above the bubble point and below the dew point before proceeding with the flash calculation.

AVAILABILITY: The intracompany report covering this program (TCC #12345) is presently being rewritten to conform to A.I.Ch.E. standards.

Note 1. All abstracts published in CEP will conform to the headings in this sample. Any abstracts not submitted in this format will be returned to the originator.

Note 2. All questions concerning programs described in the abstracts are to be sent to A.I.Ch.E. in New York. Companies or Universities submitting abstracts will be under *no obligation* to answer inquiries from any source other than A.I.Ch.E.

* *Leon Cooper, Monsanto Chemical Company; F. A. Landee, Dow Chemical Company; J. W. Kellett, Esso Research & Engineering; J. D. Seader, California Research Corporation; F. D. Parker, Arthur G. McKee Company; R. L. Pigford, University of Delaware; and E. I. Organick, University of Houston.*



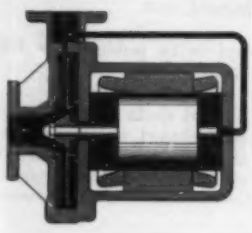
Chempump eliminates frequent shutdowns

handling hot caustic at Delmar Chemical Company

These two *Chempumps* are on the job 24 hours a day, 7 days a week at Delmar Chemical Company, Elkton, Md. They circulate caustic through scrubbing towers for gas purification, and have completely eliminated excessive shutdowns caused by conventional pump stuffing box and seal problems.

These dependable, leakproof pumps are out of operation only for a simple annual replacement of bearings, their only wearing parts. *Chempumps* have no seals, no stuffing box, no packing. No external lubrication is needed, since bearings are constantly lubricated by the pumped fluid itself. Caustic can't leak out and air cannot enter the pump.

Chempump offers many exclusive advantages in any chemical handling application. It would be well worth your while to check them. For details concerning your specific application, write to Chempump Corporation, 1300 E. Mermaid Lane, Philadelphia 18, Pa. Engineering representatives in over 30 principal cities in the United States and Canada.



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Computers

from page 86

and at least 25 in 1960.

The Machine Computation Committee needs the immediate help of individual engineers in three categories:

First—A number of competent persons are needed on the Committee.

Second—A larger number of competent, experienced persons are needed to review and to "test" programs in their installations.

Third—An even larger number of persons with the same qualifications are needed to submit general-purpose programs and abstracts of computer procedures that have been found to produce useful results.

Qualified persons should contact the Machine Computation Committee, A.I.Ch.E., New York.

Format and Procedure for publication of computer program manuals

FORMAT

Identification
Serial No. (by A.I.Ch.E.), title, originator, etc.

Description
Engineering principles, equations, mathematical methods; machine requirements, accuracy, error stop listing.

Diagrammatic Flow Chart
Problem-oriented; clear definition of decision steps, convergence tolerances; standard symbols.

Program Code *(1)*
Source language or machine language; annotated, with operating instructions.

Sample Problem(s)
Input sheets; output format

PROCEDURE

Submission
Send to Machine Computation Committee, c/o A.I.Ch.E., New York.

Assignment to Reviewers
Volunteer work, according to subject, machine used, location.

Reviewing
Rerun sample problem, compare with other programs.

Approval for Publication
By Machine Computation Committee.

Publication *(1)*
By A.I.Ch.E.; price determined by size, demand, cost.

Errata
Write-ups to be published in CEP when found.

Note (1): If card decks or tapes are to be included, the manual will describe how they may be obtained from the originator.

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UNFOLD CARD AND CIRCLE NUMBERS

SUBJECT GUIDE to advertised products and services

EQUIPMENT

Analyzers, colorimetric (p. IBC). "Quantichem" analyzers available for oxygen (0 to 30 ppb), silica (0-50 ppb), residual chlorine (0-3 ppm), hardness (0-3 ppm), also for phosphates, hydrazine, chlorides, etc. Technical data from Milton Roy Co. **Circle 42.**

Anodes, carbon (p. 18). Engineered to highest standards. Data from Great Lakes Carbon Corp. **Circle 26.**

Castings (p. 121). Technical data from Kutztown Foundry & Machine Corp. **Circle 39.**

Castings, high-alloy (p. 107). General Catalog 3354-G from Duraloy Co. contains data on corrosion, high-temperature problems, abrasion. **Circle 15.**

Coils, heating (p. 125). Provide agitation without mechanical means. Technical data from Dean Products, Inc. **Circle 13.**

Condenser, evaporative, vacuum (p. 11). Data on the "Aquamizer" from Graham Mfg. Co. Uses no external source of water. **Circle 28.**

Condensers, impervious graphite (p. 36). Long, economic life in corrosive service. Technical data from National Carbon Co. **Circle 46.**

continued on page 94

MATERIALS

Alkanolamines and Derivatives (p. 31). Properties, applications, handling and storage methods, in Bulletin from Union Carbide Chemicals Co. **Circle 72-3.**

Alkylene Amines (p. 31). Recommended as effective curing agents or hardeners for liquid and solid types of epoxy resins. Bulletin from Union Carbide Chemicals Co. **Circle 72-2.**

Butanol (p. 31). Technical data in Bulletin from Union Carbide Chemicals Co. **Circle 72-4.**

Coatings, protective (p. 42). Data Book from U. S. Stoneware, Plastics and Synthetics Div., gives complete details on Tygon Hot Spray, other Tygon coatings. **Circle 74.**

Filteraids (p. 90). Data from Great Lakes Carbon Corp., Dicalite Dept., on 10 standard grades of Dicalite filteraids. **Circle 24.**

Filteraids (p. 116). Technical Data Brochure from Sil Flo Corp. Prices and samples also available. **Circle 67.**

Filter Cloth, metallic (p. 8). New Catalog E from Newark Wire Cloth Co. **Circle 45.**

Filter Paper (p. 118). Technical data and free samples available from Eaton-Dikeman Co. **Circle 19.**

continued on page 94

SERVICES

Design and Construction, alkylation plants (p. 12-13). Brochure from Fluor Corp. titled "Alkylation Plants" is a brief guide to the various processes available. **Circle 23.**

Design and Construction, process plants, Europe (p. 30). Badger Manufacturing Co. announces acquisition of Badger-Comprimo, The Hague, of which new name will be Badger N. V. **Circle 5.**

Design and Construction, process plants, processing equipment (p. 84-85). Data from Dorr-Oliver on its facilities in U. S. and abroad. **Circle 16.**

Fabrication, process equipment (p. 114). Technical data from Downingtown Iron Works. **Circle 18.**

Fabrication, process equipment (p. 103). Data from Edw. Renneburg & Sons Co. on dryers, coolers, furnaces, reactors, presses, pilot plants. **Circle 56.**

Fabrication, process equipment (p. 15). Sprout, Waldron & Co. offers the "A" section of a dictionary of products processed in SW unit machines. **Circle 61.**

continued on page 94

MISCELLANEOUS

Automobiles (p. 28). Engineering data from Oldsmobile Div., General Motors Corp. **Circle 47.**

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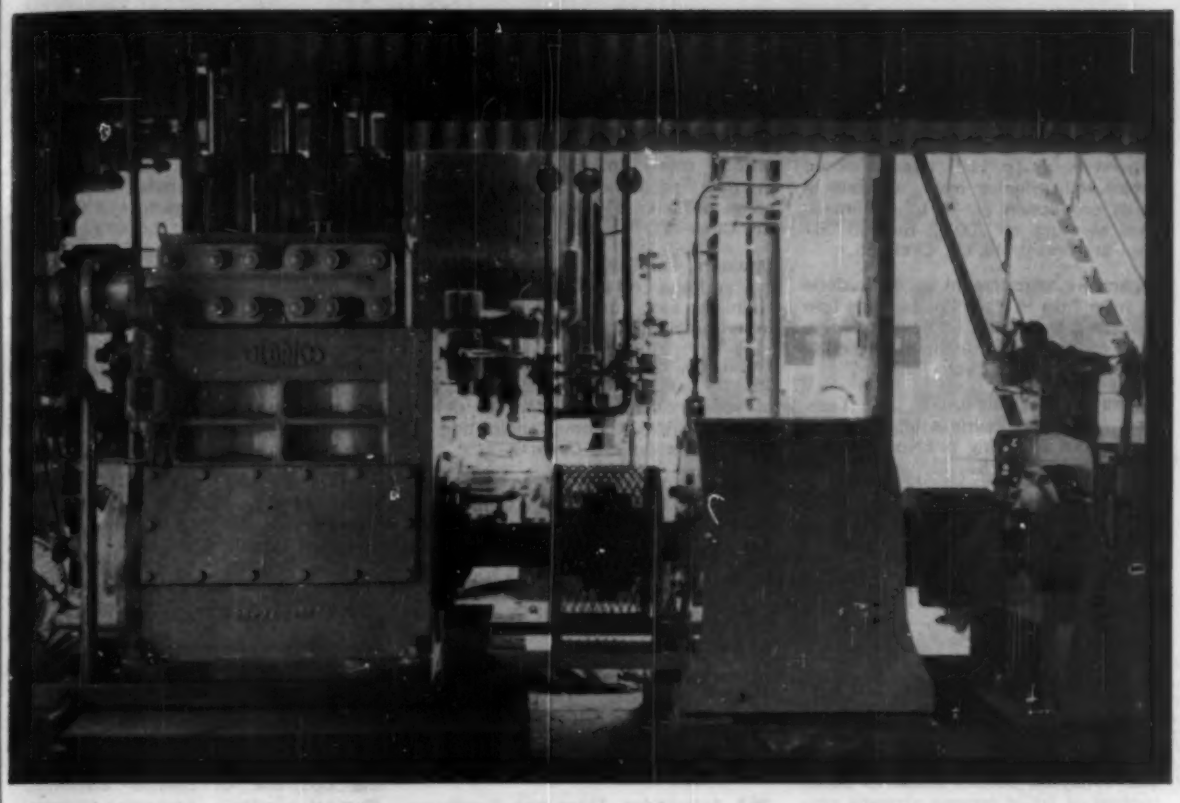

THE PRESSURES ARE HIGH...THE LIQUIDS CORROSIVE...THE PUMPS ARE ALDRICH...

At the Houston plant of Rohm & Haas Co., this Aldrich pump alternately introduces caustic and brine into one phase of the acrylate process for producing acrylic monomers.

The problem: Handle highly corrosive liquids at 3000 psi in a continuous process and *not* have severe maintenance problems.

What Rohm & Haas did about it. Company engineers specified Aldrich 1¼" x 5" stroke Triplex Pumps for three reasons.

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CEP's DATA SERVICE—Subject guide to advertised products and services

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD, PAGE 93

Equipment *continued from page 92*

Control Systems, graphic (p. 124). Booklet BE-10 from Graphic Systems. **Circle 27.**

Detectors, electronic (p. 121). Low-voltage inspection instrument indicates pinholes, voids, or bare spots in surface coatings. Details from Tinker & Rasor. **Circle 71.**

Distillation Equipment (p. 111). Technical data on redistributors, automatic reflux heads, automatic reflux splitters, packing support plates, stills, columns, complete distillation plans. Distillation Engineering Co. **Circle 14.**

Dryers (p. 17). Complete testing laboratory facilities available from Louisville Dryer Div., General American Transportation Corp. **Circle 30.**

Equipment, glassed steel (p. 29). Full details in Bulletins 968 and 932 from Pfaudler. **Circle 54-1.**

Equipment Components, nuclear (p. 16). Data Memorandum 23 from Superior Tube Co. describes fabrication facilities for the reactive metals. **Circle 62.**

Fans, corrosion-resistant (p. 121). Bulletins from Heil Process Engineering Corp. gives sizes, complete specifications. **Circle 33.**

Feeders, chemical (p. 118). Tank, agitator, and pump combined in one package unit. Data from Neptune Pump Mfg. Co. **Circle 44.**

Feeders, vibratory (p. 104). Technical data in Catalog from Syntron Co. **Circle 63.**

Filters (p. 106). Data on horizontal and vertical tank, vertical leaf pressure filters, filter presses, from T. Shriver & Co. **Circle 57.**

Filters (p. 37). Eimco Corp. offers consulting services on filtration, sedimentation, clarification problems. **Circle 21.**

Filter Presses (p. 105). Reference Manual of erection, operation, design and construction data, specifications. D. R. Sperry & Co. **Circle 68.**

Heads, safety (p. 14). Evaluation and consulting services available from Black, Sivalls & Bryson, Inc. **Circle 7.**

Heat Exchangers (p. 88). Bulletin 158-HE from Doyle & Roth Mfg. Co. **Circle 17.**

Heat Exchangers, plate-type (p. 83). Pressures to 175 lb./sq. in., high heat transfer, easy cleaning. Data from American Heat Reclaiming Corp. **Circle 2-2.**

Heat Exchangers, spiral-type (p. 83). Self-cleaning, full counterflow, high heat transfer, compact. Data from American Heat Reclaiming Corp. **Circle 2-1.**

Heat Exchangers, zirconium and titanium (p. 29). Bulletin 949 from Pfaudler. **Circle 54-2.**

Heat Transfer Equipment, glassed-steel (p. 29). Bulletins 921 and 968 from Pfaudler. **Circle 54-3.**

Heaters, steam-jet (p. 27). Complete details on all types contained in Bulletin 3A from Schutte and Koerting Co. **Circle 69.**

Indicators, bin-level (p. 119). Detailed technical data on standard and explosion-proof units. Bin-Dicator Co. **Circle 6.**

Ion Exchangers (p. 99). Consulting services available from Industrial Filter & Pump Mfg. Co. on all types of ion exchange systems. **Circle 36.**

Joints, expansion, packless (p. 101). Bulletin EJ-59-50 from Adsco Div., Yuba Consolidated Industries, Inc. **Circle 77.**

Laboratory Ware, fused quartz (p. 126). Technical data from Thermal American Fused Quartz Co. **Circle 70.**

Mixers (p. 32-33). Complete mechanical design information, selection data in Catalog A-27 from Philadelphia Gear Corp. **Circle 53.**

Mixers (p. OBC). Condensed Catalog from Mixing Equipment Co. shows all types. Bulletin 109. **Circle 43-6.**

Mixers, laboratory and small-batch (p. OBC). Bulletin 112 from Mixing Equipment Co. **Circle 43-5.**

Mixers, portable (p. OBC). ⅛ to 3 hp. Bulletin 108 from Mixing Equipment Co. **Circle 43-3.**

Mixers, side-entering (p. OBC). 1 to 25 hp. Bulletin 104 from Mixing Equipment Co. **Circle 43-4.**

Mixers, top-entering (p. OBC). Propeller types, ¼ to 3 hp. Bulletin 103 from Mixing Equipment Co. **Circle 43-2.**

Mixers, top or bottom-entering (p. OBC). Turbine, paddle, and propeller types, 1 to 500 hp. Bulletin 102 from Mixing Equipment Co. **Circle 43-1.**

Nozzles, spray (p. 113). Complete Catalog from Spray Engineering Co. **Circle 59.**

Packing, tower (p. 89). Comprehensive Booklet from Harshaw Chemical Co. describes application of "Tellerettes" to packed towers. **Circle 32.**

Piping, corrosion-resistant (p. 10). Bulletin TS-1A from Resistoflex Corp. describes Fluoroflex-T Type S piping system. **Circle 55.**

Presses, "floating-cone" (p. 119). For continuous automatic control of liquid or solids recovery. Details from E. D. Jones Corp. **Circle 37.**

Processing Systems (p. 25). Details from Pulverizing Machinery Div., Metals Disintegrating Co., on grinding, conveying, collecting systems. **Circle 50.**

Pulverizers (p. 7). Complete testing service available without charge from Stedman Foundry. **Circle 64.**

Pulverizers, fluid-energy (p. 102). For fine grinding in the range from 5 microns down to less than 0.5 microns. Data from Jet Pulverizer Co. **Circle 38.**

Pumps, controlled-volume (p. 38). Applications, flow charts, descriptions, specifications in Bulletin 440 from Lapp Insulator Co. **Circle 40.**

Pumps, leakproof (p. 87). Pump and motor in single unit. Temperatures to 1,000°F, pressures to 5,000 lb./sq. in. Details from Chempump. **Circle 10.**

Pumps, process (p. 95). Consulting services available from Aldrich Pump Co. **Circle 4.**

Pumps, screw (p. 117). Capacities from 1 to 2,000 gal./min. Horizontal or vertical construction. Technical data from Sier-Bath Gear & Pump Co. **Circle 58.**

Screens (p. 40). Selection Guide 26C-6177M from Allis-Chalmers gives specifications, technical details of all types of industrial screens. **Circle 1.**

Scrubbers, fume, jet-Venturi (p. 97). Complete Catalog from Croll-Reynolds Co. **Circle 11.**

continued on page 96

Materials *from page 92*

2-Methyl Pentaldehyde (p. 31). Now available in commercial quantities from Union Carbide Chemicals Co. Bulletin. **Circle 72-1.**

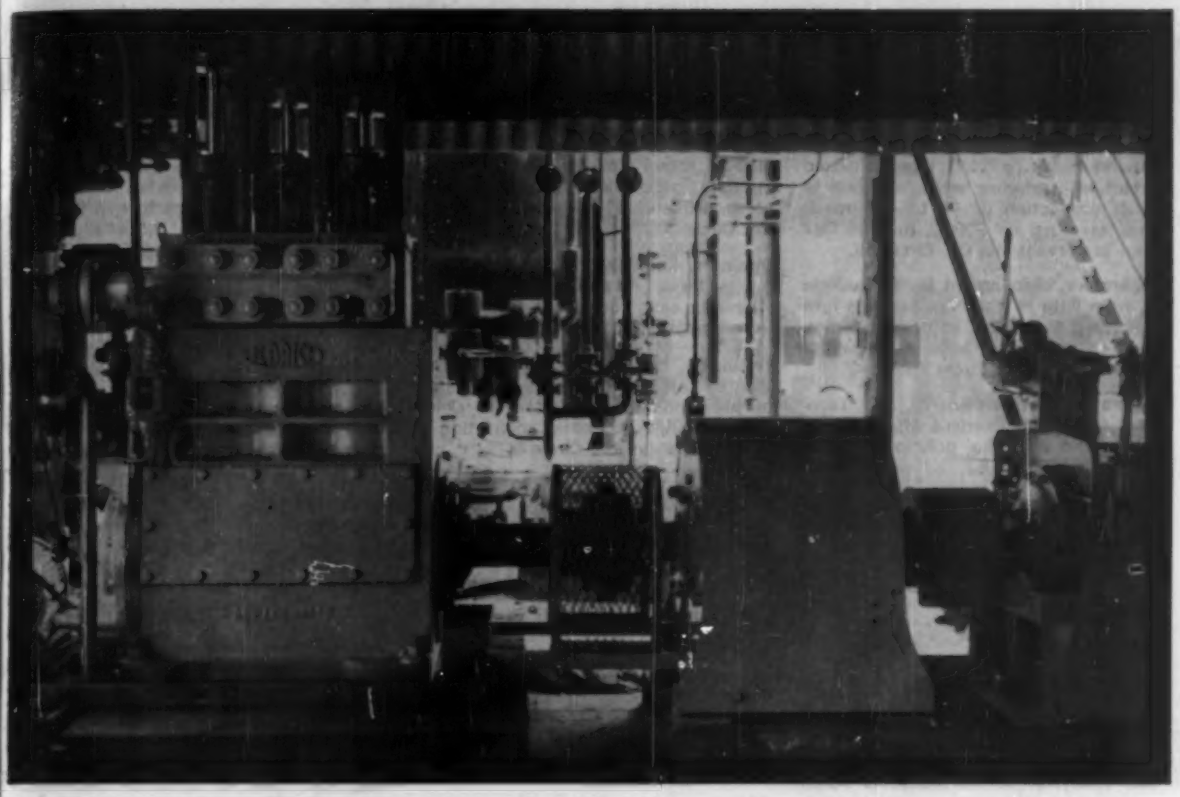
Packing, Teflon (p. 125). Technical data from Flexrock Co. on Flexrock 405 and other Teflon packings. **Circle 22.**

Sodium Alkoxides (p. 19-20). New Technical Bulletin from U. S. Industrial Chemicals Co. describes technique for preparing sodium alkoxides from metallic sodium, alcohol vapors. **Circle 73.**

Services *from page 92*

Fabrication, process equipment (p. IFC). Data on facilities from Wyatt Metal & Boiler Works, Inc. **Circle 75.**

Technical Data Books (p. 124). Listings and ordering information from Lefax Publishers. **Circle 41.**



THE PRESSURES ARE HIGH...THE LIQUIDS CORROSIVE...THE PUMPS ARE ALDRICH...

At the Houston plant of Rohm & Haas Co., this Aldrich pump alternately introduces caustic and brine into one phase of the acrylate process for producing acrylic monomers.

The problem: Handle highly corrosive liquids at 3000 psi in a continuous process and *not* have severe maintenance problems.

What Rohm & Haas did about it. Company engineers specified Aldrich 1¾" x 5" stroke Triplex Pumps for three reasons.

1. Compact, heavy-duty construction makes Aldrich pumps ideal for high pressure service.

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3. Aldrich engineers can draw upon a vast store of experience when it comes to selecting the right materials for any pumping job. In this case, the entire fluid end . . . working barrel, suction and discharge manifolds . . . are forged Monel. Valve seats are Haynes Stellite. Valves and plungers are K Monel.

Results: According to the Plant Manager of the Houston plant, "maintenance requirements have decreased and pumping production improved. These Aldrich pumps lend themselves to easy maintenance."

How Aldrich can help you. Solving pumping problems like this requires specialized engineering skills and experience. We have those skills, and our experience comes from years of working with the chemical industry. We welcome the opportunity to discuss your specific problems . . . no matter what the liquid or how high the pressures. Aldrich Pump Company, 3 Gordon Street, Allentown, Pa.

the toughest pumping problems go to ALDRICH

For more information, turn to Data Service card, circle No. 4

CEP's DATA SERVICE—Subject guide to advertised products and services

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD, PAGE 93

Equipment

from page 94

Separators, air (p. 112). Used in closed circuit with grinding mills, are said to boost production of 40 to 400 mesh fines as much as 300%. Bulletin 087 from Sturtevant Mill Co. **Circle 65.**

Separators, entrainment (p. 4). Bulletin 21 from Otto H. York Co. explains how Yorkmesh Demisters improve performance of distillation equipment, scrubbers, evaporators. **Circle 76.**

Separators, entrainment (p. 26). Technical data from Peerless Mfg. Co., on design and operating principles of line separators. **Circle 51.**

Shock Trap, bellows-type (p. 35). Technical details from Pulsation Controls Corp. **Circle 52.**

Sifters, rotary (p. 5). For single or multiple separations down to 325 mesh. Bulletin 503 from B. F. Gump Co. **Circle 31.**

Strainers, line (p. 119). For spray nozzle systems, related applications. In stainless, cast iron, brass. Bulletin 94 from Spraying Systems Co. **Circle 60.**

Television, industrial (p. 34). Blonder-Tongue Laboratories offers free survey of your industrial operation to determine possible economic application of industrial television. **Circle 8.**

Thermocouple Wells, drilled (p. 116). Bulletin 2000 from Claud S. Gordon Co. gives specifications, sizes, ordering information. **Circle 29.**

Towers, absorption (p. 110). High absorption and heat transfer rates, low pressure loss. Pressures to 465 lb./sq. in., temperatures to 3,500°F. Data from Peabody Engineering Corp. **Circle 48.**

Valves, miniature (p. 112). Catalog B-1, other technical data, from George W. Dahl Co. on line of pneumatic and hydraulic miniature valves. **Circle 12.**

Vessels, pressure (p. 111). Fabrication in any size, type, or metal. Technical data from Posey Iron Works, Inc. **Circle 49.**

Viscometers (p. 120). Technical data from Brookfield Engineering Laboratories, Inc. **Circle 9.**

CEP's DATA SERVICE—Subject guide to free technical literature

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD, PAGE 91

EQUIPMENT

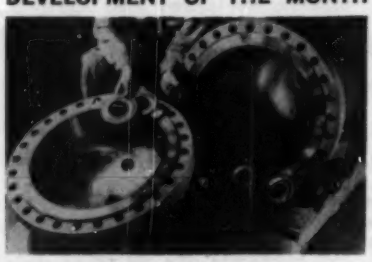
301 Agitators, side-drive. Technical Bulletin from New England Tank & Tower Co. shows design features, dimensions, specifications.

302 Analyzer, boron. Measures boron content of liquid process streams continuously to plus or minus 1% accuracy. Technical data from Mine Safety Appliances Co.

303 Blenders, ribbon-type. Completely redesigned to prevent contamination from batch to batch. Technical details from Strong-Scott Mfg. Co.

continued on page 98

DEVELOPMENT OF THE MONTH



TANTALUM-LINED REACTOR

(Circle 601 on Data Post Card)

A commercially available tantalum-lined reactor has been jointly developed by Pfaudler and Haynes Stellite.

The 30-gal. reactor illustrated is designed to operate at 650°F and 500 lb./sq. in. All surfaces that contact the product are of tantalum, including a turbine-type, tantalum-sheathed agitator shaft, solid tantalum agitator and baffle, and tantalum immersion-type bayonet heater.

Tantalum is claimed fully resistant to all acids except hydrofluoric and resistant to alkalies at moderate temperatures. According to Pfaudler, tantalum reactors can now be custom fabricated without special size or pressure limitations. For more data on this new development, Circle 601 on Data Post Card.

MATERIALS

362 Aldehydes. Physical properties, shipping data, specifications, physiological properties, bibliography. 37-page Bulletin from Union Carbide Chemicals Co.

363 Anhydrides. Three new dicarboxylic anhydride hardeners for epoxy resins described in technical Booklet from National Aniline Div., Allied Chemical.

364 Antioxidants. New, 12-page Booklet features discussion of oxidation through free radical action. Catalin Corp. of America.

365 Coatings, acrylic. Manual from Rohm & Haas titled "Acryloid Acrylic Ester Resins for Coatings" gives properties, compatibilities, uses.

366 Fatty Acids. New Brochure from Emery Industries titled "Specifications and Characteristics of Fatty Acids."

367 Glycol, anhydrous. New cross-linking agent for polyurethane rubbers, 1,4 Butanediol Anhydrous, available from Antara Chemicals, Div. of General Aniline & Film. Technical data.

368 Graphite. New, 8-page Bulletin from National Carbon Co. gives tabular data on manufactured graphite for nuclear applications.

369 Hastelloy, fabrication data. New, 36-page Booklet from Haynes Stellite Co. describes techniques for welding, forming, and finishing Hastelloy alloys B, C, D, and F.

370 Hydrogen Peroxide, explosion data. Bulletin from Becco Chemical Div., Food Machinery and Chemical Corp., titled "Prediction of the Explosive Behaviour of Mixtures Containing Hydrogen Peroxide."

371 Hydroquinone, methyl ethers. Catalog from Ansul Chemical Co. gives physical and chemical properties, specifications, toxicity, applications of hydroquinone dimethyl ether and hydroquinone monomethyl ether.

372 Organo-Metallics. More that 200 organo-metallic compounds described in new Brochure from Anderson Chemical Co., Div. of Stauffer Chemical. Physical constants, packaging information, prices.

373 Packing, biological oxidation. New, 32-page Bulletin from Dow Chemical on "Dowpac," new plastic packing material for biological oxidation of liquid wastes. Included is performance data from pilot plant installations.

continued on page 98

SERVICES

381 Chemical Reaction Data. New, 40-page Booklet from Girdler Catalysts titled "Physical and Thermodynamic Properties of Elements and Compounds," gives enthalpies, heat capacities, equilibrium constants.

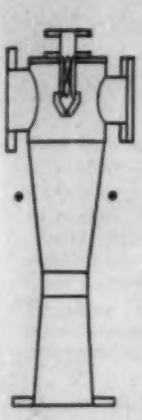
382 Design and Construction, iron ore reduction plants. Brochure from M. W. Kellogg gives details of the HyL process for direct reduction of iron ore.

383 Fabrication, process equipment. Folder from "Fey Steel" Co. describes process systems, agitators and mixers, impregnators, dryers, ball and pebble mills, tanks, process vessels.

384 Fabrication, process equipment. Pfaudler Permutit offers new 4-page Booklet "A Presentation of Facilities."

385 Testing Services. Bulletin from United States Testing Co. describes engineering services including environmental studies, instrument calibration, reliability testing, failure analysis.

386 Vessels, pressure, design data. Manual from American Car & Foundry Div., ACF Industries, titled "Pressure Vessel Design Handbook."



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For more information, turn to Data Service card, circle No. 11

CEP's DATA SERVICE—Subject guide to free technical literature

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD, PAGE 93

Equipment

from page 96

304 Blenders, rotary-batch. Small pilot models with 5, 10, and 15 cu. ft. capacity for material up to 60 lb./cu. ft. Technical data from Munson Mill Machinery Co.

309 Classifier. Buell Engineering Co. offers technical data on a new high-efficiency "gravitational" classifier said to have extremely low power consumption.

310 Column, extraction. Technical data from Podbielniak, Inc. on the Spiradyne Column Extraction Plant, a packaged solvent extraction unit available in capacities from 20 cc./min. to 20 gal./min.

314 Control Systems. Bulletin from Panellit, Inc. describes design, materials of construction, for centralized control and data presentation systems.

DEVELOPMENT OF THE MONTH

IONIZATION DETECTION
(Circle 603 on Data Post Card)

Speeds and accuracies impossible up to now are claimed for a new chromatographic system for the automatic separation, identification, and permanent recording of amounts of chemical substances present in gaseous and liquid products. The new Ionization Detection Systems, produced by Wheelco Div., Barber-Colman Co., are now offered in two standard basic sizes: Model 10, a permanent installation; and Model 20, a portable system particularly designed to meet the needs of the petrochemical industry.

The new system measures ionization current initiated by a small radioactive source, as opposed to conventional devices which measure changes in thermal conductivity of a carrier gas stream contaminated with a sample vapor. Advantages are said to be:

Superior sensitivity;

Relative insensitivity to changes in gas flow, temperature, and pressure;

Simple design, easy cleaning. For more technical data on this new development, Circle 603 on Data Post Card.

315 Conveying Systems, pneumatic. Bulletin from Buhler Brothers Engineering Works (Switzerland) describes manufacturing facilities, types, dimensions, capacities of equipment.

316 Cutters. Bulletin from Taylor, Stiles & Co. describes full line of industrial cutters.

319 Feeders, vibrating. New Catalog from Syntron Co. gives data and specifications on 5 standard feeders with vibrated hoppers with capacities of 1¼ to 3 cu. ft.

320 Filters, vertical pressure. Design details, diagrams of filter cycles, data on auxiliary equipment contained in Bulletin from Duriron Co.

324 Furnaces, testing. Bulletin from Hevi-Duty Electric Co. describes furnaces for determination of compression strength of coke or ore at temperatures to 3,000°F.

327 Heat Exchangers, impervious graphite. Bulletin from Falls Industries, Inc. gives dimensions, capacities, operating characteristics on standard models from 21 to 470 sq. ft. heat transfer surface.

328 Heat Transfer Equipment. Specifications and selection data on line of storage water heaters and heat exchangers. Standard dimensions, weights and connections, line diagrams, typical applications. Patterson-Kelley Co.

331 Indicator-Controller, ratio. Technical Data Sheets from GPE Controls, Inc. on new simplified, electrical system. Hook-up diagrams and complete specifications.

332 Laboratory Ware, plastic. Bulletin from Scientific Plastics lists lab equipment in polyethylene, polyurethane, polypropylene, polyvinyl, Nylon.

333 Manometers, well-type. Full details and specifications in Catalog from King Engineering Corp.

334 Mills, dry grinding. Forty-three-page Bulletin from Hardinge Co. describes applications of dry grinding mills and accompanying accessories.

339 Power Drives, variable-speed. Designed specially for agitators and mixers. Technical data from U. S. Electrical Motors.

340 Processing Units, batch. Packaged units in variety of designs for exothermic and endothermic reactions under wide range of operating pressures and temperatures. Details in Bulletin from Artisan Metal Products, Inc.

342 Pumps, centrifugal, all-plastic. Capacities from 10 to 180 gal./min., heads to 100 ft., temperatures to 140° F. All wetted parts of unplasticized polyvinyl chloride. Technical data from Vanton Pump & Equipment Corp.

343 Pumps, ceramic. Heads to 180 ft., capacities to 600 gal./min., maximum temperature 400°F. Technical details, line drawings in new Bulletin from General Ceramics Corp.

348 Rotameters, O-ring seal-type. Specification Sheet from Brooks Rotameter Co. gives full design, capacity, and dimension details.

349 Seals, mechanical. For pumps, agitators, autoclaves, similar chemical processing equipment. Design and technical data in Bulletin from Chemical & Power Products, Inc.

350 Separators, cyclone. Technical data from Torit Mfg. Co. describes new cyclones, operating in the 2,000-3,000 cu. ft./min. range.

353 Transmitter, temperature. Bulletin from Taylor Instrument gives technical details of a new "Sensaire" temperature transmitter with range from minus 30 to plus 1,200°F.

357 Turbines, gas. Bulletin from Clark Bros. Co. details operating experience with the Mark TA 750/1000 kw gas turbine. Design features, types of fuel, applications in process industries.

Materials

from page 96

374 Plasticizers, epoxy. Technical Bulletin from Emery Industries gives data on three new epoxy plasticizers recommended as stabilizers in all vinyl formulations.

375 Propellents, for aerosol products. New Bulletin from Pennsalt Chemicals Corp. gives vapor pressure tables, other technical data on complete line of "Isotron" propellents.

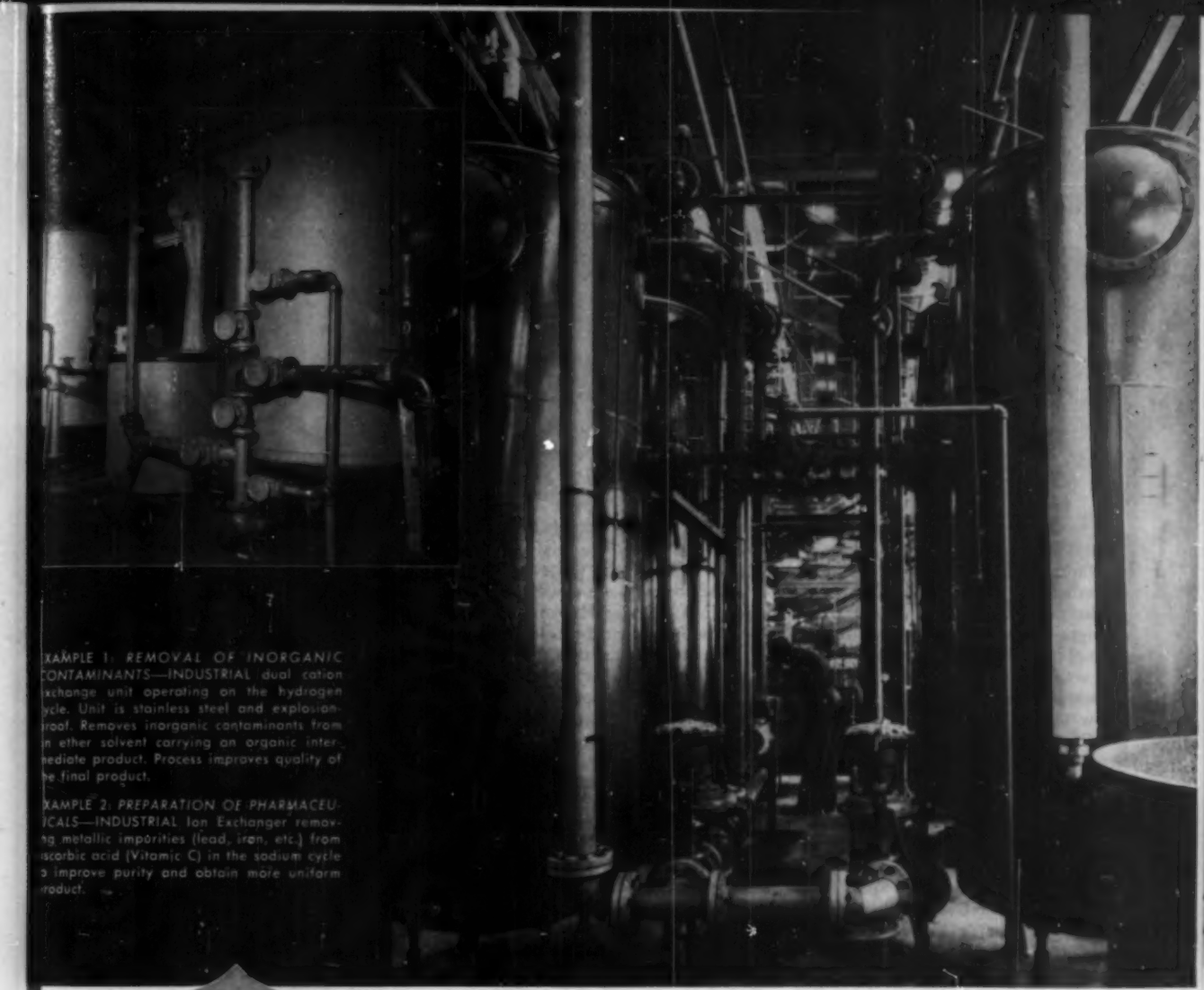
376 P-tert-Butylphenol. Now available in commercial quantities from Stepan Chemical Co. Bulletin, prices, samples.

377 Resins, ion exchange. Bulletin from J. T. Baker Chemical Co. contains technical data on nature, applications, and evaluation of ion exchange resins and techniques.

378 Silicon Carbide. Comprehensive Bibliography from Carborundum Co. is a 107-page listing of scientific literature on silicon carbide.

379 Titanium Alloy. Mallory-Sharon Metals Corp. announces new titanium alloy MST 881, said to be superior in strength to steel for long periods at temperatures of 1,100°F, and for short times to 1,500°F.

380 Urethanes. Reference Guide from National Aniline Div., Allied Chemical, contains new research material, definitions of technical terms, lists equivalent weight of reactants.



XAMPLE 1: *REMOVAL OF INORGANIC CONTAMINANTS*—INDUSTRIAL dual cation exchange unit operating on the hydrogen cycle. Unit is stainless steel and explosion-proof. Removes inorganic contaminants from an ether solvent carrying an organic intermediate product. Process improves quality of the final product.

XAMPLE 2: *PREPARATION OF PHARMACEUTICALS*—INDUSTRIAL Ion Exchanger removing metallic impurities (lead, iron, etc.) from ascorbic acid (Vitamic C) in the sodium cycle to improve purity and obtain more uniform product.

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Every day INDUSTRIAL Ion Exchangers are *replacing* expensive, complicated processing equipment in the purification of literally hundreds of chemical products. Why? Because INDUSTRIAL has successfully adapted the newest developments in ion exchange research to simple techniques. This new equipment provides advantages like these: NO HOLD-UP TIME . . . LOWER CAPITAL INVESTMENT . . . LOWER OPERATING COSTS . . . PLUS—PURITY STANDARDS TO MEET VIRTUALLY ALL REQUIREMENTS!

The operating simplicity of these new techniques permits immediate integration of an INDUSTRIAL Ion Exchanger in almost any continuous chemical process. The views on this page show some current specialized applications.

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Atlantic City

. . . The Technical Program

LEWIS C. MARINO, *Benzol Products Co.*

Headline maker at the up-coming National Meeting in Atlantic City (March 15-18) will be the Sunday afternoon panel discussion on *Rockets, Missiles, and Satellites*. The technical program committee has deemed this panel of sufficient national importance to warrant nationwide television coverage—negotiations to this end are now under way.

Panel chairman will be G. C. Szego, manager, Space Propulsion Operation, General Electric. Supporting panelists will be: Thomas Dixon, chief engineer, Rocketdyne Division, North American Aviation; H. W. Ritchey, vice-president, Thiokol Chemical; R. F. Mettler, vice-president, Space Technology Labs; and K. A. Ehricke, asst. technical director, Convair Astronautics.

A program for dissemination of information on available translated Russian literature is the goal of a second unusual session (Monday afternoon). Every chemical engineer with any knowledge of the Russian language or Russian technical literature is urgently urged to attend this panel discussion to contribute his experience and ideas to a vital purpose. Moderator for the discussion will be H. E. Hoelscher of Johns Hopkins.

The management theme runs strongly through the Atlantic City program, with a series of symposia cutting across the whole field. *Market Research and the Chemical Engineer* will detail the collection, assimilation, and interpretation of market research information, its influence on company policy and on the individual engineer. In the session on *Computer Control of Processing Units*, first-time descriptions will be given of actual computer installations for completely automatic control of chemical and petroleum processing plants. Twenty leading chemical and petroleum companies will be analyzed for development potential as one part of the symposium on *Business and Technology*. Included in the session on *The Care and Feeding of Executives* will be discussions of: proper compensation for the executive and the potential executive; the ten principles which emerged from General Electric's research on the basic factors in career development; specific management methods developed by Du Pont.

For supervisory engineering personnel also, the program will offer much solid fare. *Recent Advances in Plastic Materials of Construction* will amount to an up-to-the-minute course in the chemical processing applications of plastics, with special emphasis on fatigue, design features, strength of materials, corrosion problems.

In the symposium on *Laboratory and Pilot Plant Techniques*, a new idea in audience communication will be assessed. Each paper will be preprinted and made available before the session. In addition, each author will make a summary condensation of his paper—these summaries will also be available to the audience. At the actual session, each author will speak for only five minutes, the rest of the time being allotted to open discussion from the floor.

continued on page 102

4 Day Schedule of Sessions

SUNDAY, MARCH 15

3:00 to 5:00 P. M.

TECHNICAL SESSION NO. 1—PANEL ON ROCKETS, MISSILES AND SATELLITES.
Chairman: C. C. Szego, Manager, Space Propulsion Div. of G. E.
Panel will clarify the roles played by the bewildering variety of liquid and solid propellant rockets in terrestrial missions and will also explore the missions capabilities and limitations involved in satellites and space travel. In contrast to the material previously given by people not really in the know, these are the facts given by the people who are running our missile program . . . these are the real authorities in the field.

Liquid Fueled Rockets, T. Dixon, Rocketdyne.

Solid Fueled Rockets, H. W. Ritchey, Thiokol.

Terrestrial Missions and Capabilities, R. Mettler, Space Technology Labs Inc.

Satellites and Space Travel, K. A. Ehricke, Convair Astronautics.

MONDAY, MARCH 16

9:00 A. M. to 12 Noon

TECHNICAL SESSION NO. 2—MARKET RESEARCH AND THE CHEMICAL ENGINEER-APPLICATIONS.
Chairmen: R. Criner & M. Geisdorf, W. R. Grace Research and Development.

Marketing Research in the Chemical Company, C. P. Sanborn, Wyandotte Chemical Co. What kind of people are required to collect information, interpret, forecast, and apply market research to company plans? How can the Ch.E. use this service?

Marketing Research for the New Plant, H. E. Wessel, Virginia-Carolina Chemical Corp. Consideration of all the details involved in plant location: availability of raw material sources, estimates of future sales and selling prices, and estimates of P&L statements.

Locating New Uses and Markets, R. C. Sweeny, Sinclair Chemicals Inc. Describes details of how to locate new uses and markets for chemicals.

Market Research and Long-Range Planning, R. Williams, Jr., Roger Williams Economics Inc. Market research as it affects the overall planning program of the company.

9:00 to 11:45 A. M.

TECHNICAL SESSION NO. 3—RECENT ADVANCES IN PLASTIC MATERIALS OF CONSTRUCTION.
Chairmen: M. P. X. Gigliotti, Plastics Division, Monsanto, and C. C. Winding, Cornell Univ., Ithaca, N. Y.

Engineering Properties of Plastics, C. H. Adams, Monsanto R. & D. General relations of physical properties to engineering behavior are reviewed; effects of recent polymerization technology upon the engineering properties of plastics highlighted.

Use of Plastics for Corrosion Protection in the Chemical Industry, H. W. Schmidt & A. R. Gabel, Dow Chemical Co. Design factors in construction of plastic equipment for chemical industry featured.

continued on page 102

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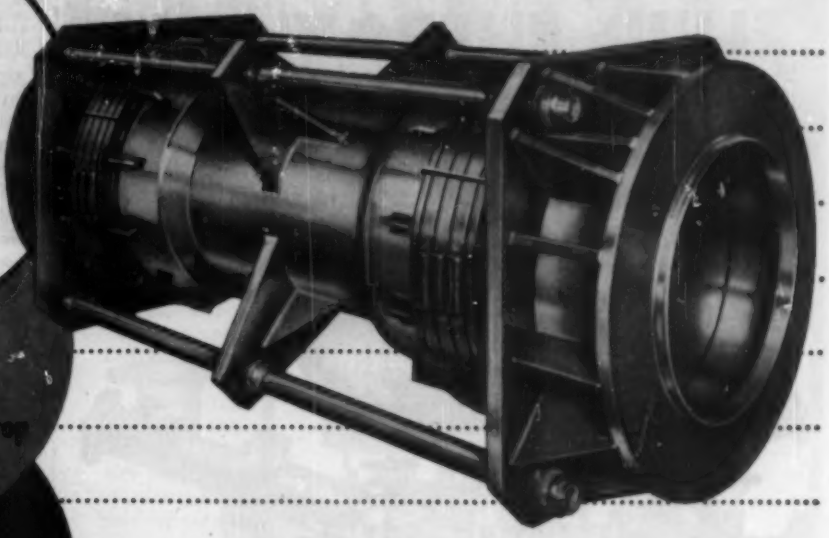
+ lower heat loss
+ minimum space
+ lower pressure drop
+ minimum cost



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Atlantic City

from page 100

Start-up of New Chemical Plants will concentrate on the more practical aspects of the subject—contractor relationships, training of production and maintenance personnel, anticipating maintenance problems. Of particular interest will be pointers on start-up using digital computer control. *Process Data and Design Methods for Nuclear Fuel Recovery* will cover a young but increasingly important branch of chemical engineering.

For the chemical engineer of more specialized interests, the sessions on *Theoretical and Laboratory Work on Liquid-Liquid Extraction, Thermodynamics of Solutions, Thermal Stability of Jet and Rocket Fuels,* and *The Mechanics of Fluid Particle Systems* are sure to offer one or more not-to-be missed topics. Worthy of special note is the symposium on *Wood as a Chemical Raw Material.* This is believed to be the Institute's first attempt to present a comprehensive treatment of the wood chemicals and their present and future significance.

Special events at Atlantic City will include: a Get-Acquainted Party (Sunday evening) with cocktails and music; Monday's luncheon with a distinguished political figure (as yet unannounced) as guest speaker; the traditional Banquet on Tuesday night, followed by dancing; a Bridge Tournament, a Golf Party, and a Bowling Party, all on Wednesday afternoon. Additional attractions will include a special guided tour of the Brigantine Native Wild Life Refuge, sailboating and fishing trips, a varied ladies program, and a long list of plant tours.

Schedule—*continued*

Use of a Modified Flexure Tester to Estimate Strength Changes in Plastics due to Corrosive Exposures, R. P. Lee & D. L. Hawke, Titanium Div. of National Lead. Describes inexpensive table-top apparatus.

Significant Design Factors for Plastic Materials of Construction, A. G. H. Dietz, M. I. T. The stress/strain/time/environment behavior of plastics is of fundamental importance in structural design. Legal restrictions, safety, public acceptance and familiarity with plastics by engineers, architects and builders must also be considered.

9:00 A. M. to 12 Noon

TECHNICAL SESSION NO. 4—THEORETICAL AND LABORATORY WORK ON LIQUID-LIQUID EXTRACTION.
Chairman: R. E. Treybal, N. Y. U.

Theory of Interfacial Turbulence—Hydrodynamic Instability and the Marangoni Effect, C. V. Sternling & L. E. Scriven, Shell Development Co. Origin of interfacial turbulence is explained in terms of classical flow, diffusion and surface processes. Theory is important to extraction studies.

Mass Transfer Inside Drops, A. I. Johnson & A. E. Hamielec, University of Toronto. Various mechanisms were examined for mass trans-

fer of organic solvents into moving water drops.

Axial Mixing and Extraction Efficiency, C. A. Sleicher, Jr., Shell Company. Theoretical analysis of backmixing in extraction towers developed on a digital computer; also, extractor design and scale-up described.

Longitudinal Dispersion in Packed Extraction Columns, T. Vermeulen, G. L. Jacques, J. E. Cotter & T. Miyauchi, University of California. Correlation of data from packed columns indicate that dispersion often outweighs mass transfer as controlling factor of axial mixing.

Effect of Mixer Design on the Efficiency of a Pump-Mix Mixer-Settler, A. T. Davis & T. J. Colven, DuPont, Aiken, S. Carolina. Volumetric heat transfer coefficient in a large pump-mix mixer-settler correlated with speed, diameter and height of mixer.

9:00 A. M. to 12 Noon

TECHNICAL SESSION NO. 5—GENERAL PAPERS.
Chairmen: J. Joffe, Newark College of Eng. & E. P. Johnson, Princeton University.

Mathematical Analysis of the Rotary Kiln Heat Exchanger, M. Imber, Bklyn Polytechnical Inst. & V. Paschkis, Columbia Univ. Temperatures of the gas and charge in a simplified model of a rotary kiln.

Machine Computation of Natural Convection Inside a Horizontal Cylinder, W. R. Martini & J. W. Carr III, Los Alamos Scientific Lab., S. W. Churchill, U. of Michigan. Numerical solution of partial differential equations to check experimental measurements.

Effects of Superheat and Surface Roughness on Boiling Coefficients, H. M. Kurihara & J. E. Myers, Purdue University. Prediction of boiling coefficients from superheat, surface roughness, and liquid properties.

Promotion of Dropwise Steam Condensation with Silicone Resin, O. K. Kullberg, Dow Corning, & H. B. Kendall, Case Institute of Technology. Study of resin film coatings on a copper tube to promote dropwise steam condensation.

Thermal Conductivity of Insulating Powders, W. Schotte, DuPont, Wilmington, Del. Prediction of thermal conductivity of insulating powders as a function of pressure, temperature and particle size.

2:00 to 5:00 P. M.

TECHNICAL SESSION NO. 6—MARKET RESEARCH AND THE CHEMICAL ENGINEER-TECHNIQUES.
Chairmen: W. Copulsky & K. G. Mayurni, W. R. Grace Research & Development.

Survey and Comparison of Techniques, R. Berger, General Aniline & Film Corp. Discussion of sales forecasting techniques, short-term and long-term.

Correlation Analysis, R. I. Chien & G. J. Bayern, W. R. Grace & Co. Discussion and evaluation of statistical correlation techniques.

The Input-Output Method, R. E. Johnson, Western Electric Co. The technique of analysis by inter-industry studies.

Operations Research, J. P. Magee, A. D. Little Inc. Operational research uses a mathematical model to describe economic phenomena simply and quantitatively.

2:00 to 4:30 P. M.

TECHNICAL SESSION NO. 7—RECENT ADVANCES IN PLASTIC MATERIALS OF CONSTRUCTION.
Chairman: M. P. X. Gigliotti, Plastics Division, Monsanto.

Plastic Piping Systems for the Chemical Industry, H. E. Atkinson, DuPont, Wilmington, Del. A status review of plastic piping systems and engineering design requirements.

Factors Involved in the Development and Testing of an Improved ABS Polymer for Use in Plastic Piping, R. L. Knapp & M. S. Thompson, Naugatuck Division of U. S. Rubber Co. A case history of the development of a specific plastic material for piping applications.

Comprehensive Review and Specific Case Histories of Plastic Materials in Structural Applications, T. F. Anderson & R. E. Barnett, Haveg Industries, Inc. Examples of plastic applications in equipment and structures.

continued on page 104

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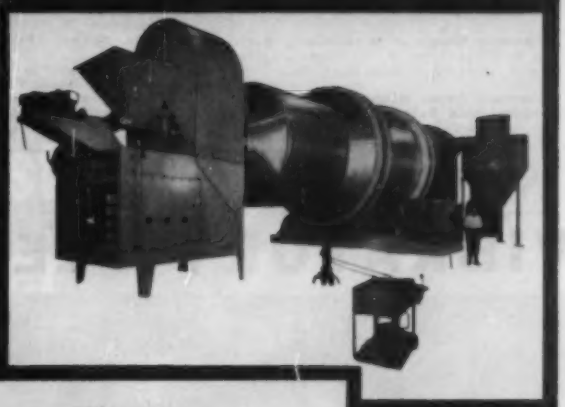

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Atlantic City

from page 103

2:00 to 5:00 P. M.

TECHNICAL SESSION NO. 8—THEORETICAL & LABORATORY WORK ON LIQUID-LIQUID EXTRACTION.
Chairman: R. B. Beckman, Carnegie Tech.

Mass Transfer Between Emulsified Liquid Phases. V. G. Trice, Argonne National Lab. Concept that solid dissolution rates are governed by mass-transfer coefficients similar to flow of two immiscible liquids supported by measurements.

Economic Design of Mixer-Settler Extractors. R. E. Treybal, N. Y. U. Procedures for economic scale-up of laboratory data.

Dispersed Phase Holdup in a Rotating Disc Liquid-Liquid Extraction Column. E. Kung & R. B. Beckman, Carnegie Inst. of Technology. Radio-isotope technique to determine correlation data for column parameters.

Continuous Extraction of Uranium in a Multi-stage Agitated Column. R. E. Treybal, N. Y. U., R. A. Gustison & R. H. Capps, Electro-Metallurgical Div. of UCC. Description and correlation of pilot-plant study data for uranium extraction from acid-leach liquors.

Performance of a Reciprocating Plate Extraction Column. A. E. Karr, Hoffman-La Roche. New column design provides low HETS and high flow capacity.

TECHNICAL SESSION No. 9 — GENERAL PAPERS.
Chairmen: E. J. Johnson, Princeton U. & J. Joffe, Newark College of Engineering.

Heat Transfer to Liquid Streams in Packed Tubes Containing Large Packings and its Analogy Relation to Pressure Drop. B. Chennakesavan, Johns-Hopkins Univ. Correlations for heat transfer and pressure drop.

Kinetics of the Absorption of Phosgene into Water and Aqueous Solutions. W. H. Manogue, DuPont, Wilmington, Del. & R. L. Pigford, U. of Delaware. Absorption rates interpreted with the unsteady state absorption-plus-reaction theory.

Initiation of the Homogeneous n-Butane-Oxygen Reaction. J. F. Skrivan, U. of Delaware, & H. E. Hoelscher, Johns-Hopkins U. Information on the initiation reactions in the homogeneous oxidation of butane.

A Simplified Method for Determining Thickener Areas. C. M. Thatcher, U. of Michigan. Application of the Kynch analysis to determine area requirements in continuous thickeners.

Bench-Scale Pilot Plants. D. E. Garrett, American Potash Corp. Several specific pilot plant designs and studies described.

TUESDAY, MARCH 17

9:00 A. M. to 12 Noon

TECHNICAL SESSION NO. 10—COMPUTER CONTROL OF PROCESSING UNITS.
Chairmen: J. M. Mosley, Jr., Johns-Hopkins Hospital, & T. J. Williams, Monsanto.

The Roll of Computers in Process Control. J. E. Bertram, I.B.M. The problems requiring solution to apply computers to process control.

What's Available for Computing Control. H. R. Karp, McGraw-Hill Publishing Co. Review of commercially-available computing controllers.

An Investigation of Direct Digital Computer Control of a Simulated Chemical Reactor. L. Lapidus, Princeton U., R. E. Kalman, Res. Inst. for Adv. Study, R. W. Keopcke & E. Shapiro, I.B.M. A large scale analog-digital system is described.

An Optimalizing Process Control. D. E. Archer, Carnegie Institute of Technology. Operating results of computer control of a catalytic reactor and problems in application to a distillation column.

9:00 A. M. to 12 Noon

TECHNICAL SESSION NO. 11 — PROCESS DATA AND DESIGN METHODS FOR NUCLEAR FUEL.
Chairman: C. E. Stevenson, Phillips Petroleum, Idaho Falls, Idaho.

Design of Underground Storage Tanks for Radioactive Waste. E. Doud, General Electric Co., Hanford Works. Highly radioactive wastes can be safely stored but means for removing heat from decaying fission products must be provided.

Design Information for Nuclear Fuel Solvent Extraction Systems. W. L. Carter, J. T. Long & A. M. Rom, Oak Ridge National Laboratory. Uranium and plutonium recovery by liquid-liquid extraction of nitrates of the metals using as solvent either tri-n-butyl phosphate, or methyl isobutyl ketone.

Heat and Mass Transfer in Mixer-Settlers. D. S. Webster, DuPont, Savannah River. Correlation established between heat and mass transfer rates in solvent extraction.

Preliminary Evaluation of Processes for Zirconium Fuels. P. Burn & J. I. Stevens, Phillips Petroleum. Costs appear to be similar for various methods to process anticipated enriched zirconium clad fuels.

Development and Design Concepts for a Hanford Radiocesium Packaging Facility. L. C. Amos, R. J. Sloat & R. W. Wirta, General Electric Co., Hanford Works. Planned small plant for recovering and packaging million-curie quantities of cesium-137.

9.00 A. M. to 12 Noon

TECHNICAL SESSION NO. 13—THERMODYNAMICS OF SOLUTIONS.
Chairman: E. H. Amick, Jr., Columbia U.

Application of the Theory of Corresponding States to Multi-component Systems. T. W. Leland, Jr. & W. H. Mueller, Rice Inst. of Technology. Validity of extending the law of corresponding states to multi-component systems confirmed by use of digital computer.

Solubility of Liquids in Compressed Gases. J. M. Prausnitz & P. R. Benson, U. of California. Thermodynamic correlations of various gas-liquid pairs show how molecular shape of liquid affects its vapor-phase solubility. Cor-

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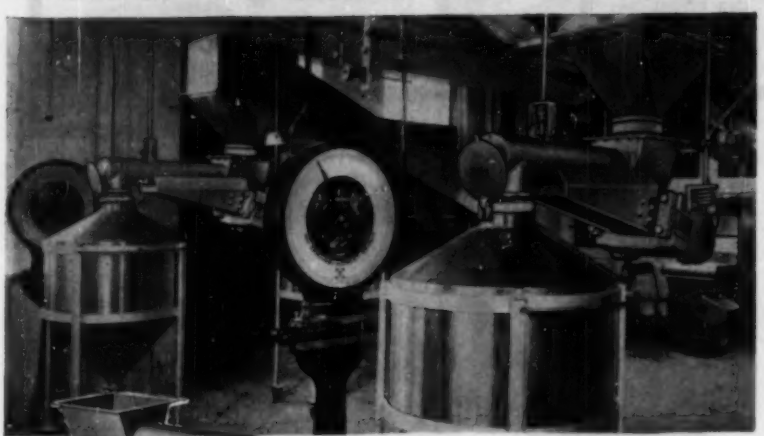

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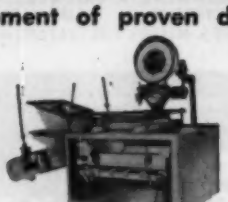

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relation used to predict gas-liquid equilibria for CPI operations.

Hydrocarbon Vapor-Liquid Equilibria and Solubility Parameter, J. M. Prausnitz & K. C. Chao, U. of Calif., W. C. Edmister, Oklahoma State U. Various hydrocarbon vapor-liquid equilibria expressed in terms of "K" values computed by interesting methods.

The Differential Manometer in Vapor-Liquid Equilibrium Studies, W. A. Salmon & W. E. Gordon, A. D. Little Inc. Differential manometer used to measure differential pressures between O_2 or N_2 and their mixtures.

The low Temperature Heterogeneous Phase Behavior of the Methane-Hydrogen Sulfide-Carbon Dioxide System, F. Kurata & D. P. Sobocinski, U. of Kansas. An attempt to extend knowledge of a binary system to a ternary system.

9:00 A. M. to 12 Noon

TECHNICAL SESSION NO. 13 — GENERAL PAPERS.
Chairmen: E. F. Johnson, Princeton U. & J. Jaffe, Newark College of Engineering.

Phase and Area Contributions to Mass Transfer Kinetics, A. J. Teller, U. of Florida. Quantitative description of factors affecting packed column performance.

Interfacial Resistance Due to Thin Films of Alcohols and its Effect on Rate of Evaporation of Water, L. H. Udani & K. F. Gordon, U. of Michigan. A study of four alcohols.

Fixed Bed Isothermal Reactors, R. G. Zelmer, Standard Oil of Indiana, & R. E. Peck, Illinois Inst. of Technology. Mathematical theory and performance charts for heat and mass transfer in fixed bed reactors.

Mechanisms by which Ultrasonic Energy Affects Transfer Rates in Liquid-Liquid Extraction, H. A. Woodle & F. C. Vilbrandt, Virginia Polytechnic Inst. Co-current and spray tower studies of effects of ultrasonic insonation.

Dispersion of Radioactive Waste in the Wake of a Nuclear-Powered Ship, R. H. Snow & J. Rosinski, Illinois Inst. of Technology. Mixing action of propeller in dispersing radioactive waste.

2:00 to 5:00 P. M.

TECHNICAL SESSION NO. 14 — BUSINESS AND TECHNOLOGY.
Chairman: J. Happel, N. Y. U.

Technologists in Business. K. M. Watson, Illinois Inst. of Technology. Evaluation of the management potential of 40 actual companies.

The Technologist in Management, E. M. Hart, Food Machinery & Chemicals Corp. Methods by which the technologist can participate in various levels of management.

The Businessman's Relationship to Technology, C. Y. Thomas, Spencer Chemical Co. Methods proven effective in establishing good relationships between businessmen and technologists.

Creative Technology in Business, I. H. Pooshee, General Chemical Co. Importance of business-technology relationships.

Intangibles of Technical Economics, D. B. Keyes, Consultant, 480 Park Ave., N. Y. C. Intangible factors involved in the economic evaluation of new products and processes, how they can be dealt with.

Conservation of Scientific and Engineering Manpower, W. G. Torpey, President's Committee on Scientists and Engineers. Recommendations for better use of manpower resulting from survey.

2:00 to 5:00 P. M.

TECHNICAL SESSION NO. 15—LABORATORY AND PILOT PLANT TECHNIQUES.
Chairmen: G. W. Blum, Goodyear Tire & Rubber Co., & J. T. Cumming, Penn College.

Fractional Factorial Experiments in Chemical Engineering, F. C. Leone, Case Institute of Technology. Use of experimental mathematical models result in cost and time saving in pilot plant studies.

Scale-Up Aspects of the Pilot Plant, D. Q. Kern, D. Q. Kern Associates. Thermal processing industries are appropriate for using prediction tools in scale-up of pilot plants to commercial design.

The Performance of a Computer Controlled Pilot Plant, E. C. Boycks, W. Priestley, Jr. &

continued on page 106

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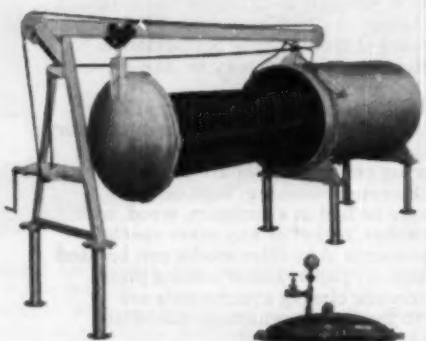

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W. F. Taylor, Esso Research & Development. Combination of computer, pilot unit, and automatic controls reduces process development time, manpower needs and number of runs required for data determination.

The Design and Layout of a Pilot Plant for Elastomers. P. M. Lindstedt, C. T. Winchester, K. G. Roquemore & E. W. Campbell, Goodyear Tire & Rubber Co. Requirements for operating flexibility for scale-up of polymerization processes.

Application of Chemical Reaction Kinetics in Process Scale-Up. T. E. Corrigan, Olin Mathieson. Reaction kinetics used to scale-up a chemical reactor for specific reactions.

2:00 to 5:00 P. M.

TECHNICAL SESSION NO. 16—THERMAL STABILITY OF JET & ROCKET FUELS.
Chairman: C. J. Marsel, N. Y. U.

Thermal Stability of Jet Fuels. A. D. Skelton, Wright Air Development Center. Correlations of laboratory thermal stability data with service experience. Projected future requirements for hydrocarbon fuels of extreme thermal stability.

Experimental Evaluation of the Thermal Stability of Rocket Fuels. E. G. Jackson & W. S. Hines, Rocketdyne. Fuel stability and thermodynamic correlations studied in simulated rocket conditions.

Thermal Stability of Petroleum Fuels. G. D. Kittredge, Phillips Petroleum. Stability studies of a variety of petroleum fractions, and investigation of special handling and processing of fuels for subsonic, low supersonic, and high supersonic speeds.

Logistics of Some Thermally Stable Hydrocarbon Fuels. E. E. Donath & M. Hess, Koppers Co. Production of hydrocarbon fuels for supersonic aircraft and missiles discussed on basis of availability and cost of required raw materials.

Thermal Stability of Liquid High Energy Fuels. F. Leighton & P. A. Stranges, Olin Mathieson. Data summary of factors influencing thermal stability of high energy fuels.

2:00 to 5:00 P. M.

TECHNICAL SESSION NO. 17—MECHANICS OF FLUID PARTICLE SYSTEMS.
Chairman: S. K. Friedlander, Johns-Hopkins U.

The Motion of Two Spheres in a Viscous Fluid. J. Happel, N. Y. U. Comparison of experimental results with theory of spheres falling through viscous liquid.

The Effect of a Cylindrical Boundary on Solid Spherical Particles Suspended in a Moving Fluid. J. Happel, N. Y. U. Experimental comparison with theory.

The Behavior of Particles Suspended in Fluids Subjected to Laminar Shear. S. G. Mason, Pulp & Paper Research Inst. of Canada. Experimental and theoretical results of interactions of particles suspended in a sheared fluid.

The Mechanics of Particle Bounce. W. E. Ranz, G. R. Talandis & B. Gutterman, U. of Minnesota. Bouncing investigated w/respect to backmixing, dust collection and energy loss.

A Study of Solid Particle Distributions in a Gas-Solid Jet. E. E. Peterson & A. Acrivos, U. of California. Similitude representation of solids distribution.

Solids-Air Jets. L. A. Madonna, U. of Ottawa, Ottawa, Canada. "Fountain-like" flow described; and methods of correlating data developed.

WEDNESDAY, MARCH 18

9:00 to 11.40 A. M.

TECHNICAL SESSION NO. 18—CARE AND FEEDING OF EXECUTIVES.
Chairmen: J. S. Wilson, Heidrick & Struggles, & R. H. Rogge, Corn Products Rfg. Co.

Enlightened Salary Administration at the Management Level. R. B. Blomfield, Union Carbon & Carbide Chem. Corp. Types of com-

pensation and incentive plans used in the chemical industry today.

Management Development. R. C. Wellford. DuPont, Wilmington, Del. Not theory! but review of specific management development methods.

How Do People Grow in a Business Organization? M. Wright. General Electric Co., Ossining, N. Y. Results of a comprehensive survey to identify basic factors involved in the development of people.

9:00 to 11:30 A. M.

TECHNICAL SESSION NO. 19—START-UP OF NEW CHEMICAL PLANTS.
Chairmen: M. L. Nadler, DuPont, Chambers Wks. and R. L. Cummings, Atomics International.

Chemical Operator Training in Start-Up of New Plants. P. A. Van Tassel, J. H. Field & P. W. Pontius, Union Carbide & Chemical Corp. Data based on practical experience.

Organization and Preparation for Start-Up of a Unifiner-Platformer. E. P. Barnett, Union Oil Co. Definition of responsibilities among process licenser, design and construction contractor, Home Office, and refinery.

Anticipating Maintenance Problems in a New Plant. T. W. Tomkowit, DuPont. A well-planned program for anticipating and solving maintenance problems is necessary for successful start-up.

Relations Between Contractor and Client During Plant Start-Up. J. P. Eames, Stone & Webster Engineering Co. Contractor start-up effort extends continuously from the initial design to successful plant operation.

9:00 to 11:30 A. M.

TECHNICAL SESSION NO. 20—WOOD AS A CHEMICAL RAW MATERIAL.
Chairman: E. G. Locke, Forest Products Laboratory.

[Wood as a] Raw Material Supply for Chemical Utilization. E. G. Locke, Forest Products Laboratory. No shortage of this renewable source appears on the horizon.

Kinetics of the Acid Catalyzed Conversion of Glucose to Hydroxymethyl Furfural and Levulinic Acid. S. W. McKibbins, J. F. Harris & W. E. Neill, U. of Wisconsin. Glucose disappearance rate in acid-water system measured over wide range of parameters.

Economics of the Production of Furfural from Xylose Solutions. J. F. Harris & J. M. Smuk, U. of Wisconsin. Estimated production costs indicate that many crude xylose solutions can be profitably processed to furfural.

The Tall Oil and Sulfate Turpentine Industry. J. F. Davis, Arizona Chem. Co. (N. Y.). By-products of the sulfate wood pulp process as basis raw material for the CPI.

Production of the Bleachable Pulp in Continuous Digesters. U. J. Westbrook, St. Regis Paper Co. Control and operation of stationary-type continuous digester.

9:00 to 11:30 A. M.

TECHNICAL SESSION NO. 21 — GENERAL PAPERS.
Chairmen: J. Joffe, Newark College of Engineering, & E. J. Johnson, Princeton U.

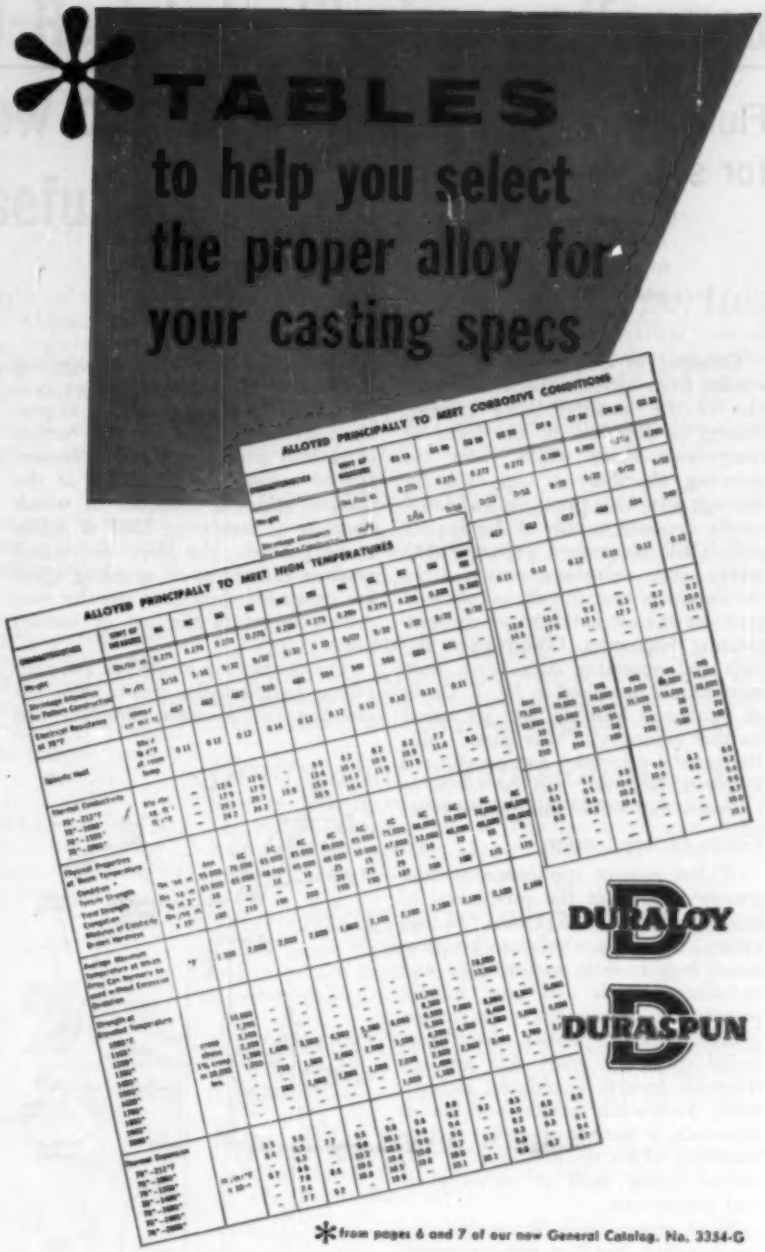
Eddy Dispersion in Ordered and Random Packings. G. L. Jacques & T. Vermeulen, U. of California. Studies of single-phase flow through arrangements of spheres, rings and saddles.

Propylene-Propane Vapor-Liquid Equilibria. A. B. Hill, Esso Research & Development Co. Isobaric volatilities determined from isothermal equilibrium in the literature.

Precision Fractionaters for Pentane Isomerization Pilot Plant. C. D. Ackerman, Gulf Research & Development. Design and operation of two continuous precision fractionating towers.

Radiological Study of Liquid Holdup and Flow Distribution in Packed Gas Absorption Columns. C. S. Hwa & R. B. Beckman, Carnegie Inst. of Technology. Study of local flow characteristics in two-phase contacting equipment.

Continuous Throughput Rectification of Organic Liquid Mixtures w/Vertical, Countercurrent Thermal Diffusion Columns. D. R. Longmire, U. of Wisconsin. Experiments w/ cylindrical thermal diffusion columns in which curvature effects could be ignored.



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ATLANTA OFFICE: 76—4th Street, N.W.
CHICAGO OFFICE: 332 South Michigan Avenue
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For more information, turn to Data Service card, circle No. 15

Fluid energy mills for sub-sieve pulverizing

Smaller particle size, increased surface area, seen of increasing importance in processing of metals, ceramics, abrasives

Grinding in all fluid energy mills results from attrition between particles of the material being ground. Energy is supplied in the form of compressed fluids which enter the grinding chamber at high velocity through jets. This principle is diametrically opposed to that of the impact mill (CEP, November, 1958, p. 134) where size reduction results from the impact of centrifugally-accelerated particles against stationary or counter-rotating impactors. Construction details and operating data given here were kindly furnished by W. T. Doyle of Sturtevant Mill Co. and are based on that company's "Micronizer" mill: the general principles and conclusions involved, however, can be taken to represent any mill of this general type.

Fields of Application

Widest present application of fluid energy mills is in the production of materials below 325 mesh (44 microns). Materials which can be processed include both non-metallic and metallic minerals and ores, metals, pigments, insecticides, fungicides, pharmaceuticals, plastics, dyes. Generally speaking, solids that are not frangible cannot be reduced satisfactorily. Such solids include most fibrous materials, a number of dactyl metals, materials which resist shattering, and certain resins such as polyethylene and polystyrene.

Fluid energy mills, being designed for superfine grinding, require considerable energy. Therefore, in some cases, the most economical method of operation consists in grinding the material as fine as economically feasible in conventional mills (ball, roller, or hammer), and then feeding the product to the fluid energy mill for final pulverizing.

Construction details

General construction details of the Sturtevant-designed energy mill are shown in Figure 1. The machine employs a relatively flat cylindrical grinding chamber. An aspirating venturi feeder utilizes part of the compressed fluid for injecting the feed into the grinding chamber through an opening in the top or bottom plate, or tangentially as near the periphery as possible. Processing involves the action of gaseous jets emerging from nozzles spaced around the periphery of the shallow grinding chamber in which there is a circulating load of solids to be ground. The finely pulverized product and the spent grinding agent are exhausted through a circular concentric outlet in the top or bottom plate.

The nozzles are located in the peripheral wall with the axes of their jets pointing in the same direction and tangent to a circle of smaller diameter than the grinding chamber. The compressed gases issuing through these jets maintain a high speed of rotation in the grinding chamber. Solids fed into the grinding chamber are accelerated by the rotating gases and are thrown to the periphery, where that portion coming into the zone of action of a nozzle is further accelerated tangentially and radially inward. This action causes violent impact between the particles thus accelerated and other particles circulating at a much slower velocity in a thin band near the periphery. The fines resulting from the continuing series of impacts are carried by the rotating gases in an inwardly spiraling path toward the central outlet.

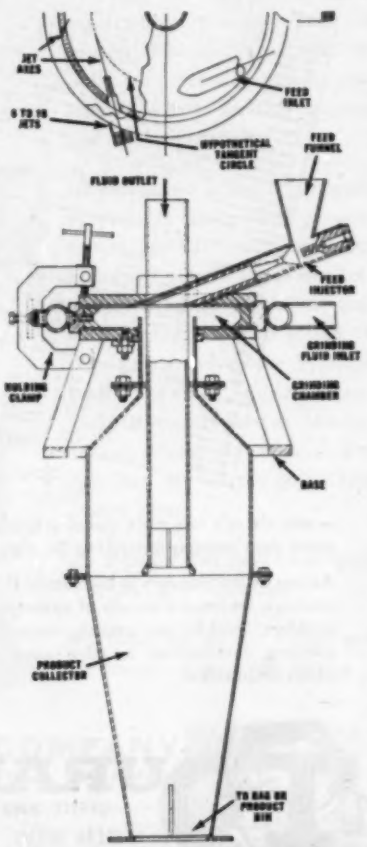


Figure 1: Schematic drawing of Sturtevant fluid energy-type mill.

Since the solids travel in the vortex at substantially constant tangential velocity, they are subjected to an intense classifying action as they approach the outlet: the centrifugal force returns oversize particles to the grinding zone, while the entrainment force of the gas carries the finer particles to the outlet.

The spent grinding fluid bearing the fine solids is normally passed through a cyclone-type collector which is integral to and directly below the machine itself. In this way, the rotational speed of the gases leaving the mill is preserved and no additional energy is required to obtain maximum collection in the cyclone. In effect, this means that collection of anywhere from 90 to 98% of the ground product can be achieved. Normally, the exhaust from a cyclone collector is cleaned by a bag filter or a wet collector although, in some instances, such as insecticide mixtures or mixtures containing materials of varying weights, it has been found advantageous to discharge from one point—the top of the machine—into a bag collector.

Grinding energy

Grinding energy for most commercial installations is supplied in the form of air compressed to 100 lb./sq. in. at temperatures from 40 to 1,000°F, or by steam at pressures of from 100 to 200 lb./sq. in. and temperatures from 500 to 1,000°F. The 40°F air is used for heat-sensitive materials and the higher temperature air and the steam for those applications where the material will not be damaged. The volume of compressed fluid required to grind a unit weight

continued on page 110

NOW Ni-Resist ductile irons offer you new combinations of useful engineering properties

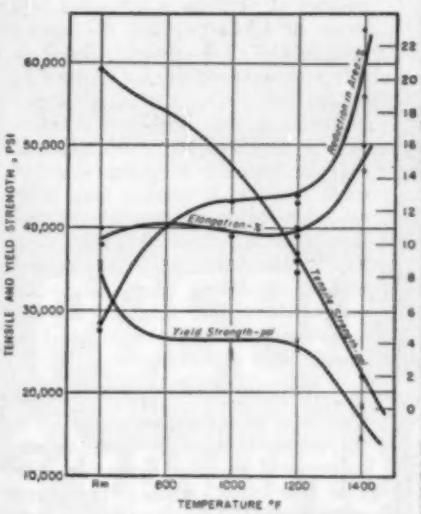
Ni-Resist* ductile irons are a new family of versatile high-alloy cast irons developed by Inco. Containing 18 to 36% Nickel, they provide the same high order of corrosion and heat resistance given by Ni-Resist flake graphite iron...plus high levels of strength and ductility.

There are several types of Ni-Resist ductile iron. Each one combines a useful array of engineering properties.

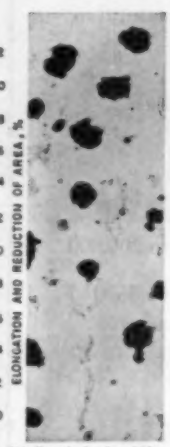
Strength Ni-Resist ductile irons provide tensile strengths of 55,000 to 80,000 psi, yield strengths of 30,000 to 44,000 psi. See graph of properties below.

Toughness Ni-Resist ductile irons give elongations of 4 to 40%, together with good impact resistance. The photomicrograph below shows why – spheroidal graphite particles allow formation of an austenitic matrix. This nickel alloy matrix develops full ductility and strength . . . keeps these properties at low temperatures.

Corrosion resistance Ni-Resist ductile irons safely handle hundreds of corrosives. Under most conditions – with acids, alkalies and salts – their performance is far superior to both cast iron and steel, helping you reduce maintenance costs.



High temperature tensile properties of Type D-2 Ni-Resist ductile iron.



Ni-Resist ductile microstructure X 100. Spheroidal graphite particles allow the metal to develop the full strength and toughness of the high alloy austenitic matrix.

High temperature properties Ni-Resist ductile irons form a tightly adhering scale at elevated temperatures, greatly reducing further oxidation. They resist heat effects up to 1400° F and higher, have excellent thermal shock resistance. From 1100° to 1300° F, Type D-2 has stress rupture properties equal to those of cast HF stainless steel.

Wear resistance Ni-Resist ductile irons have a work hardening austenitic matrix. Graphite particles provide dry lubrication. Both properties work together to resist wear and galling over a wide temperature range.

Erosion resistance Ni-Resist ductile irons work well in wet steam, brine or salt slurries, and high velocity liquids. Their high strength and resistance to cavitation-erosion mean long service life for pump parts.

Controlled expansion Ni-Resist ductile irons have thermal expansivities from about 2.5 up to 10.4 millionths per degree F. You can match them with steels, cast irons, Nickel, Monel* alloy...with aluminum, copper, bronze and stainless steel.

Non-Magnetic properties Ni-Resist ductile irons, Types D-2 and D-2C, are non-magnetic and therefore useful where excessive heat and power losses must be avoided.

Machinability Ni-Resist ductile irons machine as well as common pressure-type gray iron, thanks to the presence of graphite in their structure.

Fluidity in casting Ni-Resist ductile irons have good flowing qualities and permit the making of intricate designs.

These are only the highlights. You can get *all* the facts on this versatile new family of metals by asking us for "Engineering Properties of Ni-Resist Ductile Irons." This 28-page booklet details engineering properties and commercial applications with numerous photos, tables, and graphs . . . gives you the information you need to decide how Ni-Resist ductile irons can help you. You'll also get "Buyers' Guide for Ni-Resist and Ni-Resist Ductile Iron Castings", listing foundries authorized to produce them.

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• *Economical*
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Low liquid consumption

• *Flexible*
Installation—vertical or horizontal
Pressure—1 p.s.i.a. to 465 p.s.i.a.
Material—alloys, lead, rubber, plastic
Capacity—100 to 200,000 S.C.F.M.
Temperature—to 3500° F.

• *Versatile*
Corrosive fluids
Various process cycles
Clear liquids or slurries
Several types of contact stages
Inlet dust loadings—to 100 grains/cu. ft.
Particle size—plus 20 microns to sub-micron fume

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For more information, turn to Data Service card, circle No. 48

Pulverizers

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of material is, in general, proportional to the kinetic energy of the fluid. Since it is normally more economical to generate this energy in the form of superheated steam than by compressing air, its use is recommended where feasible.

Energy costs

While energy costs for fluid energy mills are considered to be relatively high, an example may serve to show that this may not actually be the case when new surface area created is taken into consideration. If a 30 mesh (590 micron) material is reduced to 325 mesh (44 microns), the number

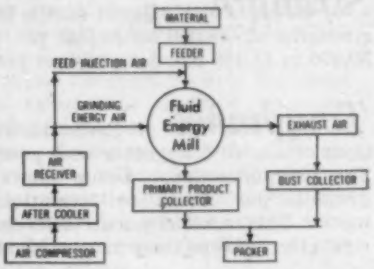

Figure 2: Typical flow diagram for fluid energy mill installation.

of particles is increased by a factor of 2,400, and the surface area is 13.4 times greater. If, however, the 30 mesh material is reduced to an average particle size of 5 microns, the number of particles is increased by a factor of 1,643,000, and the surface area is 118 times greater. Based on the generally accepted theory that the energy required for grinding is proportional to new surface created, it will be seen that 8.8 times more energy is required to grind from 30 mesh down to 5 microns than is required to grind only to 44 microns. It is claimed, further, that fine grinding in conventional mills requires higher circulating loads, and that power above that required for size reduction must often be supplied for classification and collection.

Two new air separation plants are in the works, both to be designed and constructed by Air Reduction Sales Co. One unit, with a production capacity of 120 tons per day of high-purity oxygen, will be built at Butler, Pa., for the Armco Steel Corp. The second unit will be a $600,000 facility for production of oxygen and nitrogen at Denver, Colorado, for Air Reduction Co.

For more information, turn to Data Service card, circle No. 14

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1. LARGE SIZE REDISTRIBUTOR: (now built in sizes up to 90") Collects and distributes liquid evenly over the packing, minimizes channeling and keeps packing wet and at maximum efficiency at all liquid rates. Especially suitable for vacuum distillation. Can be used with all types of packing and readily installed in any installation.

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The above items are available in most materials of construction and in sizes 2" and larger.

ALSO AVAILABLE: Packing support plates, distributor plates, stills, columns, and complete distillation plants.

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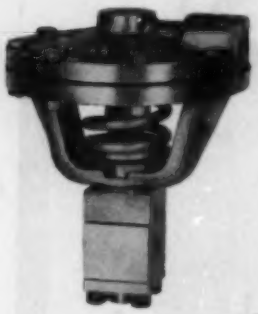
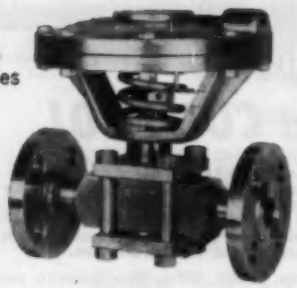
MINIATURE VALVES



501 Series



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THROTTLING CONTROL VALVES

Compact throttling controls of the 501 series have one-piece barstock bodies with screwed ends and are available with linear, equal percentage or quick-opening plug characteristics. This series offers six operators, direct and reverse acting, including two with positioners.

The 526 series includes 6 body styles in globe, angle and 3-way design — with screwed or flanged ends. Four bonnet types cover standard, high or low temperature and packless applications. Six control operators are offered with up to 50 square-inch diaphragms.

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Pressure Rating	1000 psi (at 450°F)	1000 psi (at 450°F)
Temperature Rating	−70°F to +450°F	−70°F to +450°F (750°F with finned bonnet)
Maximum Cv.	0.63	10.0 (1" connections)
Lift	¼"	7/16"
Seat Area	0.038 sq. in.	up to 0.601 sq. in.
Connections	⅛", ¼", ½" N.P.T. Standard (others available)	¼" to 1" N.P.T. ⅓" to 1" flanged

Send for the BANTAM Catalog No. B-1 and other technical data on Dahl pneumatic and hydraulic valves.

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For more information, circle No. 12

future meetings

1959—MEETINGS—A.I.Ch.E.

• **Atlantic City, N. J. March 15-18, 1959. A.I.Ch.E. National Meeting.** Chalfonte Haddon Hall Hotel. For details, see p. 100.

• **Philadelphia, Pa. March 21, 1959. Univ. Museum, U. of Pa. All-Day meeting. New Advances in Chemical Engineering Practice sponsored by Phila.-Wilmington Section A.I.Ch.E.**

• **Cleveland, O. April 5-10, 1959. Nuclear Congress. Co-sponsored by A.I.Ch.E. and others.** A.I.Ch.E. representative: E. R. Gunyou. Alco Prods., Inc., Schenectady 5, N. Y.

• **Pittsburgh, Pa. April 9, 1959. Mellon Institute. Seminar-type Catalysis Symposium. Joint One-Day Meeting Pittsburgh, Cleveland, Toledo, Columbus, Akron, N.W. Virginia, Philadelphia-Wilmington, and National Capital Sections A.I.Ch.E.** Tech. Chmn.: R. Beckman, Carnegie Tech.

• **Kansas City, Missouri, May 17-20, 1959. Hotel Muehlebach. A.I.Ch.E. National Meeting.** Gen. Chmn.: F. C. Fowler, Consulting Chem. Engr., 7515 Troost Ave., Kansas City, Mo. Tech. Prog. Chmn.: Fred Kurata, Chem. Eng. Dept., Univ. of Kansas, Lawrence, Kansas. **Reaction Kinetics**—M. M. Gilkeson, Dept. of Chem. Eng., Tulane Univ., New Orleans, La. **Petrochemicals**—G. E. Montes, Nat'l. Petrochemical Corp., Tuscola, Ill. **International Licensing and Collaboration**—R. Landau, Scientific Design Co., 2 Park Ave., New York, N. Y. **General Papers** (3 sessions). J. O. Maloney, Univ. of Kansas, Lawrence, Kan. and Merk Hobson, Univ. of Nebraska, Lincoln, Nebr., O. H. Beyer, U. of Missouri, Columbia, Mo. **Equilibrium Fluid Mechanics**—M. J. Rzasa, Cities Services Res. Lab., P.O. Box 402, Cranbury, N. J. **Role of Wetting and Capillarity in Fluid Displacement Processes**—C. S. Kuhn, Magnolia Petroleum Co., 907 Thomasson Dr., Dallas, Tex. **Thermodynamics of Jet & Rocket Propulsion**—G. C. Szego, Gen. Elect. Aircraft & Gas Turbine Div., Cinn. 15, Ohio. **Computers and Pipelines**—R. L. McIntire, The Datics Corp., 600 Camp Bowie Blvd., Fort Worth, Texas. **Present Status of Liquid Metals Technology**—H. M. Rodekohr, Ethyl Corp., P.O. Box 341, Baton Rouge, La. **Ten Ways to Improve Technical Reports**—Robert Gunning, Blacklick, Ohio.

• **Storrs, Conn. August 9-12, 1959. Univ. of Conn. A.I.Ch.E.-A.S.M.E. Heat Transfer Conference.** Prog. Chmn.: M. T. Cichelli, Eng. Research Lab., DuPont, Wilmington, Del. Abstracts by Jan. 15, final paper deadline, March 15, 1959.

• **St. Paul, Minn., Sept. 27-30, 1959. Hotel St. Paul. A.I.Ch.E. National Meeting.** Gen. Chmn.: W. M. Podas, Asst. Rsch. Dir., Economics Lab., Guardian Bldg., St. Paul, Minn. Tech. Prog. Chmn.: A. J. Madden, Jr., Univ. of Minn. **Mixing**—J. Y. Oldshue, Mixing Equip. Co., Inc. P.O. Box 1370, Rochester 3, N. Y. **Size Reduction**—E. L. Piret, Chem. Eng. Dept., Univ. of Minnesota, Minneapolis 14, Minn. **Missile Construction Materials**—B. M. Landis, Gen. Elect. Co., Cleveland 12, O. **Physical Properties of Liquids**—S. E. Isakoff, Dupont Co., Eng. Dept., Expr. Sta., Wilmington, Del. **Molecular Engineering**—M. Boudart, Princeton U., Chem. Eng. Lab., Princeton, N. J. **Chemical Economicas as a Unit Process**—M. H. Baker, 1645 Hennepin Ave., Minneapolis 3, Minn. **More Research for Your Dollars**—T. S. Mertes, Sun Oil Co., 1608 Walnut St., Philadelphia 3, Pa. **Process Control**—I. Lefkowitz, Case Inst. of Techn., Cleveland, Ohio. **Thin Film Techniques Involving Heat and Mass Transfer**—H. J. Karakas, Lincoln Bldg., 60 E. 42 St., N. Y. 17, N. Y. **Chemical Warfare**—Co-Chmn.: L. E. Garono & E. J. Gruen, Army Chem. Corps, Bldg. 250, Baltimore, Md.

Deadline for papers: May 27, 1959.

• **San Francisco, Calif., December 6-9, 1959. A.I.Ch.E. Annual Meeting.** Gen. Chmn.: Mott Souders, Jr., Shell Development Co., 4560 Horton St., Emeryville 8, Calif. Tech. Prog. Chmn.: C. R. Wilke, Div. of Chem. Eng., Univ. of Calif., Berkeley, Calif. **Process Dynamics**—E. F. Johnson, Dept. of Chem. Eng., Princeton, J., Princeton, N. J. **Operations Research**—R. R. Hughes, Shell Dev. Co., Emeryville 8, Cal. **Progress and Problems in Jet and Rocket Combinations**—C. J. Marsel, NYU, University Heights, New York 53, N. Y. **Secondary Oil Recovery Methods**—F. H. Poettman, Ohio Oil Co., Littleton, Colo. **Financing in the Chemical Industry**—H. S. Gardner, Fibreboard Paper Prods., Box MM, Antioch, Cal. **Fundamental Progress and Problems in Jet and Rocket Combinations**—C. J. Marsel, NYU, University Heights, New York 53, N. Y. **Secondary Oil Recovery Methods**—F. H. Poettman, Ohio Oil Co., Littleton, Colo. **Financing in the Chemical Industry**—H. S. Gardner, Fibreboard Paper Prods., Box MM, Antioch, Cal. **Fundamental**

continued on page 113

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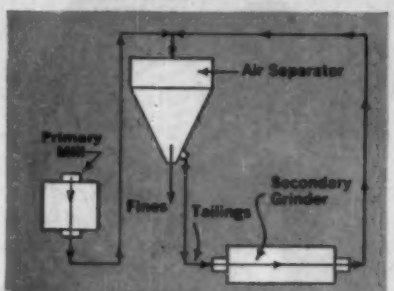
Boost Production of 40 to 400 Mesh Fines As Much As 300%



STURTEVANT CLOSED CIRCUIT SYSTEM: Primary Mill runs open, load is circulated through air separator. Desired fines are discharged. Oversize recirculates to secondary grinder and then to air separator for further classification.

Current users of Sturtevant Air Separators include manufacturers of sulfur, soybeans, phosphate, chocolate, feldspar, sand, pigments, limestone fillers, abrasives, plasters, ceramics and cement.

Sturtevant Air Separators Can Lower Power Costs Up To 50%

Production capacity impossible in single-pass grinding results from using Sturtevant Air Separators in closed-circuit grinding systems. They are of proved advantage in all secondary reduction processes.

Fines pass through grinding mills unhindered, are classified, and the oversize returns for further grinding. Grinding mills are free to perform at top efficiency, their output frequently increased as much as 300% and power costs cut up to 50% (documented by 30 years of Sturtevant air separation experience in the cement industry).

Precise Classification; Circulates Loads of 800 tph

Sturtevant Air Separators circulate production loads of up to 800 tph. Simple adjustments make possible counter-action between air currents and centrifugal force to the point where a product of almost any desired fineness may be collected while coarser sizes are rejected.

A 16 FT. STURTEVANT, for example, took a feed rate of 800 tph, containing only a small percentage of desired fines, and delivered 30 tph 90% 200 mesh, recirculating the oversize through the grinding circuit. (In the cement industry, Sturtevant units deliver up to 60 tph raw cement fines, 40 tph finished cement fines.)

Nine models available, diameters from 3 to 18 ft. For more information, request Bulletin No. 087. (Bulletins also available on Micronizers, Blenders, Crushers, Grinders.) Write STURTEVANT MILL CO., 135 Clayton St., Boston, Mass.

For more information, circle No. 65

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mental Aspects of Chemical Engineering in the Pulp and Paper Industry—J. L. McCarthy, Dept. Chem. Eng., U. of Washington, Seattle, Wash. **Turbulence and Turbulent Mixing**—T. Baron, Shell Devel. Co., Emeryville, Cal. **Electro-Chemical Engineering**—C. W. Tobias, Dept. Chem. Eng., U. of Cal., Berkeley, Cal. **Outlook for National Resources; High Temperature: Thermodynamics, Reactions, Kinetics; Devices and Materials.**

Deadline for papers: August 6, 1959.

1959—Non-A.I.Ch.E.

• Manhattan, Kansas, February 25-26, 1959. Campus of Kansas State Coll. **Midwest Industrial and Radioisotope Conf.** Co-sponsored by AEC and Kan. St. Coll. Details from J. Kitchens, Dept. Continuing Educ., K. S. Coll.

• New York City, Mar. 31, April 1-2, 1959. Auditorium Eng. Soc. Bldg. **Symposium on Millimeter Waves.** Co-spons. Dept. of Defense Resch. Agencies & IRE. Papers closing date 1/30/59; add. to H. J. Carlin, Microwave Resch. Inst., 55 Johnson St., Bklyn 1, N. Y.

1960—MEETINGS—A.I.Ch.E.

• Atlanta, Ga. Feb. 21-24, 1960. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: Fred Bellinger, Ga. Inst. of Techn., 225 North Ave., N.W., Atlanta 13, Ga.
Nuclear Engineering; Petroleum, Turpentine, and Solvents; Rubber and Plastics; Fertilizers; Chemurgy - Insecticides; Bioengineering - Radio isotopes; Pulp and Paper, Ceramics, and Metals; Engineering Sales; Rockets and Missiles.

• Mexico City, Mexico, June 20-24, 1960. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: G. E. Montes, Nat'l Petrochemical Corp., P.O. Box 109, Tuscola, Ill. **Chemical Engineering in Latin America**—John Mayurnik, Grace Chem. Co., 3 Hanover Square, New York 4, N. Y. **Petroleum Production; Minerals and Metals; Biochemicals and Foods; Equipment.**

• Tulsa, Okla., Sept. 4-7, 1960. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: E. H. Hachmuth, Phillips Petroleum Co., Bartlesville, Okla. **Foams—Their Use and Control**—C. S. Grove, Jr., Syracuse U., Collendale, Syracuse 10, N. Y. and R. L. Tuve, U. S. Naval Resch. Lab., Washington 25, D.C.

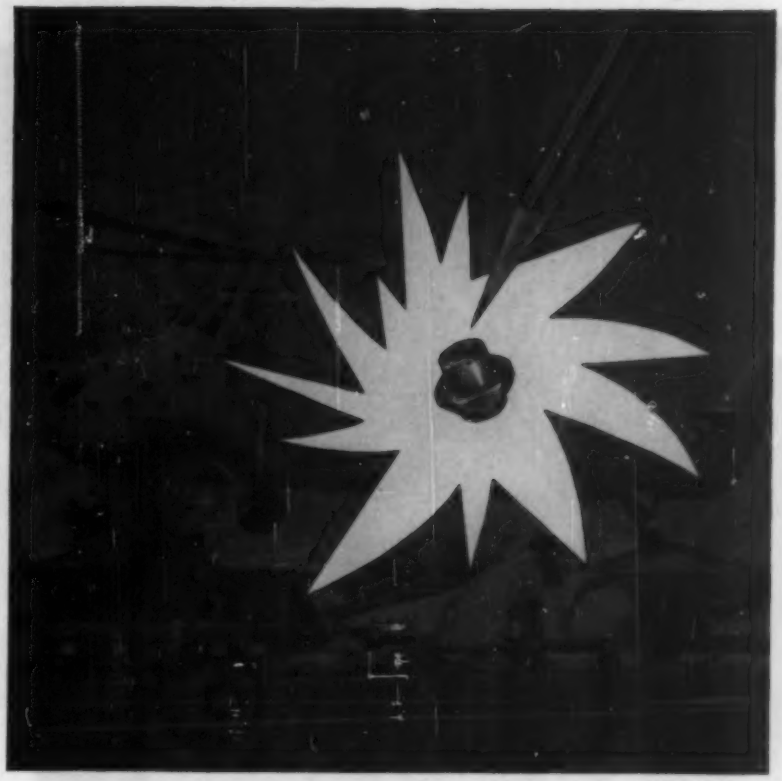
• Washington, D. C., Dec. 4-7, 1960. **A.I.Ch.E. Annual Meeting.** Tech. Prog. Chmn.: D. O. Myatt, Atlantic Research Corp., Alexandria, Va.

1960—MEETINGS—A.I.Ch.E.

• Moscow, USSR, June 1960. 1st. Congress of International Fed. Automatic Control. To cover areas of **Theory, Hardware, & Applications of automatic control.** U.S. participation sponsored by American Automatic Control Council. Affiliated societies: **A.I.Ch.E., ASME, AIEE, IRE, ISA.** A.I.Ch.E. Chmn.: D. M. Boyd, Universal Oil Prods., Des Plaines, Ill. Abstracts of papers by March 1, 1959; completed papers by July 15, 1959.

Unscheduled Symposia

Correspondence on proposed papers is invited. Address communications to the Program Chairman listed with each symposium below.
Computers in Optimum Design of Process Equipment: Chen-Jung Huang, Dept. of Chem. Eng., Univ. of Houston, Cullen Blvd., Houston 4, Texas.
Preparation of Catalytic Cracking Charge Stocks and Quality Criteria Therefor: Wheaton W. Kraft, Lummus Co., 385 Madison Ave., New York 17, N. Y.
Solar Energy Research: J. A. Duffie, Director of Solar Energy Laboratory, Univ. of Wisconsin, Madison, Wis.
Hydrometallurgy—Chemistry of Solvent Extraction: G. H. Beyer, Dept. of Chem. Eng., Univ. Mo., Columbia, Mo.
Process Dynamics as They Affect Automatic Control—D. M. Boyd, Universal Oil Prods., Des Plaines, Ill.



16 Spraco Nozzles help the new lightweight G.E. T58 engine pack the punch of a heavyweight!

At the heart of General Electric's new T58 turboshaft engine — a revolutionary new power plant for helicopters that packs over 1,000 horsepower into a 59" long, 16" diameter, 325 pound frame — are 16 precision built steel spray nozzles.

These are special nozzles, developed for the engine by Spraco engineers. Their critical function: to feed just-right amounts of fuel into the combustion chamber.

This development is another example of the hand-in-glove cooperation, engineering service, and product quality you can expect from Spraco whenever you have a spray nozzle problem.

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132 Cambridge Street, Burlington, Mass.

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A. I. Ch. E. candidates

The following is a list of candidates for the designated grades of membership in A.I.Ch.E. recommended for election by the Committee on Admissions. These names are listed in accordance with Article III, Section 8 of the Constitution of A.I.Ch.E.

Objections to the election of any of these candidates from Members and Associate Members will receive careful consideration if received before February 15, 1959, at the office of the Secretary, A.I.Ch.E., 25 West 45th Street, New York 36, N. Y.

MEMBER

Bennett, Carroll O., *Lafayette, Ind.*
Brunk, John W., *Baltimore, Md.*

Castaneda, M., *La Ceiba, Honduras*

de Ridder, G. F., *Houston, Tex.*
Dershowitz, Arthur F., *Schenectady, N. Y.*
Diggins, Earl Ready, *Pittsburgh, Pa.*
Farrar, Richard E., *Morris Plains, N. J.*
Flanigan, Orin, *Shreveport, La.*

Granville, M. F., Jr., *New York, N. Y.*
Gustavson, Donald R., *Richland, Wash.*

Hawley, Robert W., *Boulder, Colo.*
Hutto, John F., *Bartlesville, Okla.*

Krabbe, Erik, *Milwaukee, Wisc.*

Lemiska, Theodore, *Roselle, N. J.*

Massberg, A. T., *Midland, Mich.*
Martin, David P., *East Chicago, Ind.*
McCarthy, J. P., *Pittsburgh, Pa.*
Morris, Miles G., *Mars, Pa.*

Neeper, Billy M., *Akron, O.*

Opferkuch, Robert E., Jr., *Decatur, Ala.*

Pollock, James F., *New Lenox, Ill.*
Poulos, William, Jr., *Midland, Mich.*
Powell, William E., *Tuscola, Ill.*

Sanford, Robert D., *St. Louis, Mo.*
Sefer, Norman, *Minneapolis, Minn.*
Stoller, Sidney M., *Roslyn Estates, N. Y.*

Tadje, Harold W., *Salt Lake City, Utah*
Trinastic, J. C., *Miamisburg, O.*

ASSOCIATE MEMBER

Alles, Donald H., *Bound Brook, N. J.*
Ammenheuser, James M., *Cuyahoga Falls, O.*
Anderson, Earl V., *Bellaire, Tex.*
Anderson, John D., *Newark, Del.*
Arnold, Lionel C., *Algonquin, Ill.*

Bald, Paul R., *Wahpeton, N. D.*
Boscov, Joseph L., *Great Neck, L. I., N. Y.*
Briguglio, Carmine S., *Union City, N. J.*
Buxton, Richard C., *Charleston, W. Va.*

Carney, George J., *Minneapolis, Minn.*
Castro B., P., *Chuquicamata, Chile*
Chachere, Charles B., *Port Arthur, Tex.*
Chollett, Weldon E., *Houston, Tex.*
Collins, James A., *Andover, Mass.*
Cromwell, Thomas M., *Covina, Calif.*

Dalton, Paul, *Hartford, Conn.*
Delaney, Thomas J., *Cambridge, Mass.*
Delaney, W. Guy, *Pasadena, Tex.*
Djuvik, Roy H., *Pasadena, Tex.*

Emery, Durward L., *East St. Louis, Ill.*

Gerwert, Philip E., *Hazelwood, Mo.*
Gilbreth, J. H., *Lakeland, Fla.*

Harris, William D., *Berkeley, Calif.*
Holt, Ronald H., *Port Arthur, Tex.*

Jacobs, Alfred, *Wilmington, Del.*
Judd, Gene, *Park Forest, Ill.*

Kaighin, Hall Young, *Bayshore, N. Y.*
Khatchadourian, Zohrab, *Pottstown, Pa.*
Kiehne, Arthur Dan, *Benton, Mo.*
Knight, Virgil Patrick, *Springfield, Mo.*
Kuehn, Gene R., *St. James, Mo.*

Laczynski, Edward M., *St. Louis, Mich.*
Larson, Paul E., *Houston, Tex.*
Leichti, James W., *Wilmington, Del.*
Leitgeb, Joseph E., *Boston, Mass.*
Lewis, David V., *Pittsburgh, Pa.*
Lighteap, Edward H., *No. Arlington, N. J.*
Lukow, Kenneth R., *Marinette, Wisc.*

Marsello, Bernard D., *Decatur, Ala.*
Mitlo, Thomas J., *Pittsburgh, Pa.*
Mole, Joseph F., Jr., *Pasadena, Tex.*
Muller, Robert, *Clifton, N. J.*

Neilson, Wallace R., *Pittsburgh, Pa.*
Niemeyer, William G., *Troy, Ill.*

Occhipinti, Edward S., *Augusta, Ga.*

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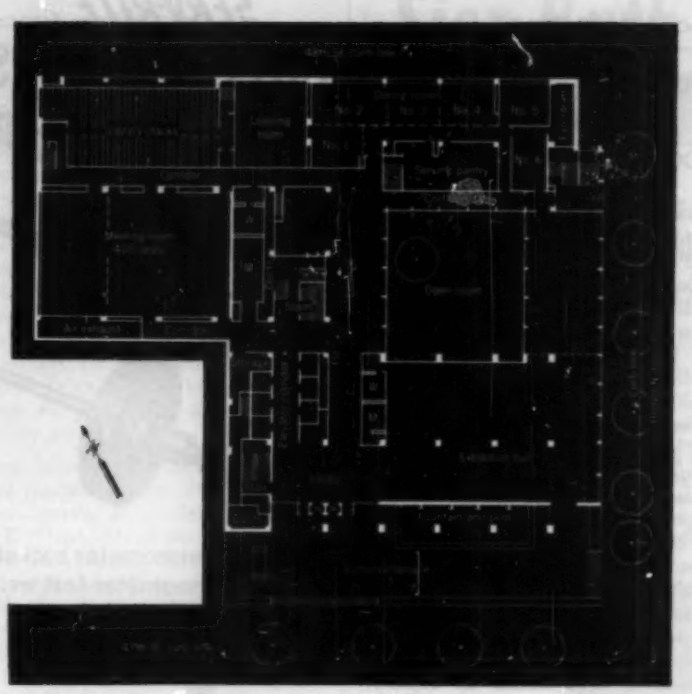
cep camera



Here is the street-floor plan of the new United Engineering Center building soon to rise on United Nations Plaza in New York city. Ground breaking will be in April of this year, construction is to start in July. Bids are already out to several large construction firms, and completion of the building for occupancy is scheduled for early in 1961.

Gala scene at the Tuesday-night Awards Banquet in Cincinnati. One of the main events of the evening was presentation of the Professional Progress Award to W. K. Davis, the William H. Walker Award to R. L. Pigford, and the Student Problem Contest awards.

Informal get-together of new officers in Cincinnati. (L. to R.): Jerry McAfee, vice-president; George E. Holbrook, outgoing president; Donald L. Katz, president; F. J. Van Antwerpen, secretary; J. Henry Rushton, treasurer.

Brimming steins and whiskers were the order of the evening at the Over-the-Rhine Party in Cincinnati.

C. Y. Thomas of Spencer Chemical makes a point at the panel session on Employment of the Chemical Engineer (Cincinnati). Other panel members—(L. to R.)—F. S. Endicott, Northwestern U.; A. J. Teller, U. of Florida; moderator Jerry McAfee.

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local sections

Two-stage cat-cracking ups product yield

Two-stage catalytic cracking offers greater process efficiency and product yield over the present conventional single-stage method now in use by half of all U.S. refineries. The first and, so far, only two-stage unit in use for two years at Shell Oil's Anacortes, Washington refinery, was described by W. V. Medlin to the **No. California section** (*W. B. Hauserman*) in October.

In all cracking operations, feed stock is brought into intimate contact with a clay or silica catalyst, at the proper temperature, so the heavy molecules are cracked into gasoline and light gases, or polymerize to form coke which must be burned off the catalyst particles. The product yield of this reaction increases *up to a point*, beyond which the gasoline yield decreases, as coke builds up rapidly. Therefore contact time is kept brief to stop the reaction at the point of maximum gasoline yield, after which the stream is fractionated; part of the uncracked feed stock being recycled. It is then a problem for the fractionation column to separate feed stock molecules that have been through only once, from those that have been through the cracking process several times. The result is that much of the feed stock is subjected to cracking only once, while some of it may pass through the catalyst bed several times . . . after its gasoline-forming potential has been exhausted. The two-stage catalytic process offers an answer to this difficulty.

In the two-stage process feed stock is introduced to the catalyst for a very short time, at a very high temperature, in a "riser" type reactor consisting of vertical tubes through which the catalyst and feed stock flow rapidly upward more thoroughly mixed, and therefore in more intimate contact than in a more conventional catalyst bed. The gases are then separated from the catalyst and fractionated; unreacted feed stock being then introduced to the second stage, which is a conventional catalyst bed. After being again fractionated, the unreacted feed stock can be recycled to either of the two stages. Advantages over conventional one-stage cracking: (1) all feed stock cracked at least once; (2) each cracking stage not too severe yielding maximum

continued on page 117

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from page 116

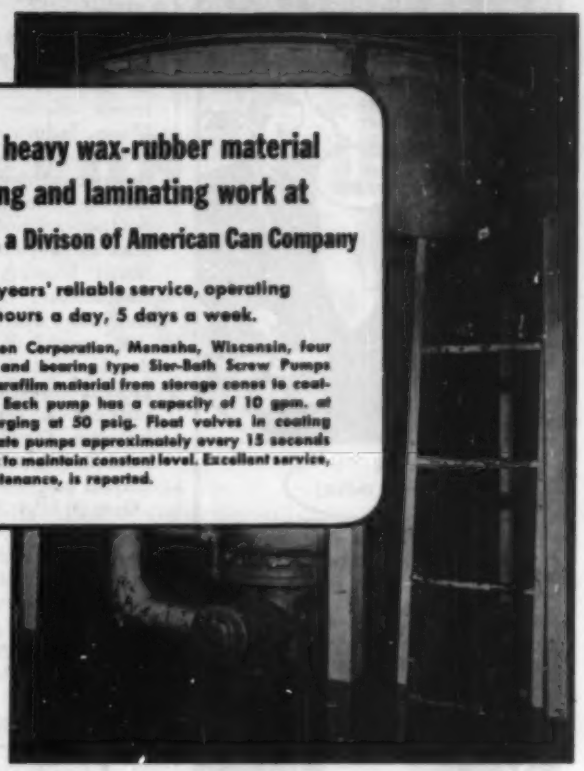
amount of gasoline; (3) due to improved reactor mechanics, first stage has unusually high gasoline-to-coke ratio; (4) each stage can be controlled separately, giving greater control over overall reaction. Initial expense of two-stage cracking is somewhat greater than more conventional single-stage operation, but the gasoline yield per barrel of feed stock is higher. Its popularity can be expected to grow any time the market favors the production of gasoline over heavier fuels.

"Less know-how; more know why! Less practical; more scientific!" With these words, F. J. Lockhart, Head Ch.E. Dept., U. of So. Cal., summarized the changing chemical engineering curriculum at **So. California section's** Oct. panel meeting *(R. D. Sheeline)*. Lockhart has studied curricula as they change with respect to industrial needs. He said that three separate approaches have been offered to allow for the increased amount of chemical engineering developed in recent years, including: increasing the length of the present four-year program; splintering the curriculum; and eliminating marginal-value courses. For a number of reasons, it seems most practical to do the latter. The basic approach to use of engineer-sciences was described by W. H. Corcoran of CalTech. He considered the advantages in six categories: material, energy, and momentum transport; chemical, kinetics, and equilibrium; and properties of matter. He felt that the Ch.E. student could properly apply his knowledge far more efficiently when he enters industry by considering these basic concepts with relation to a particular point in a chemical system rather than studying the gross effects. Former chemical engineering curricula trained men more for the immediate positions they would fill after graduation, according to W. D. VanVorst, of UCLA. More emphasis is now being given to training the chemical engineer for what he will be doing several years in the future. Certain specialized courses in such works as nuclear reactions, rocketry, statistics, computers and cost accounting are now available to undergraduates, graduates, night-school, and special short-course students on campuses, at extension centers, and industrial locations.

"An American Engineer Looked at Russia" at the September meeting of the **Northern West Virginia Section**

continued on page 118

Sier-Bath SCREW PUMPS



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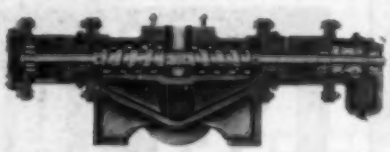
Sier-Bath SCREW PUMPS



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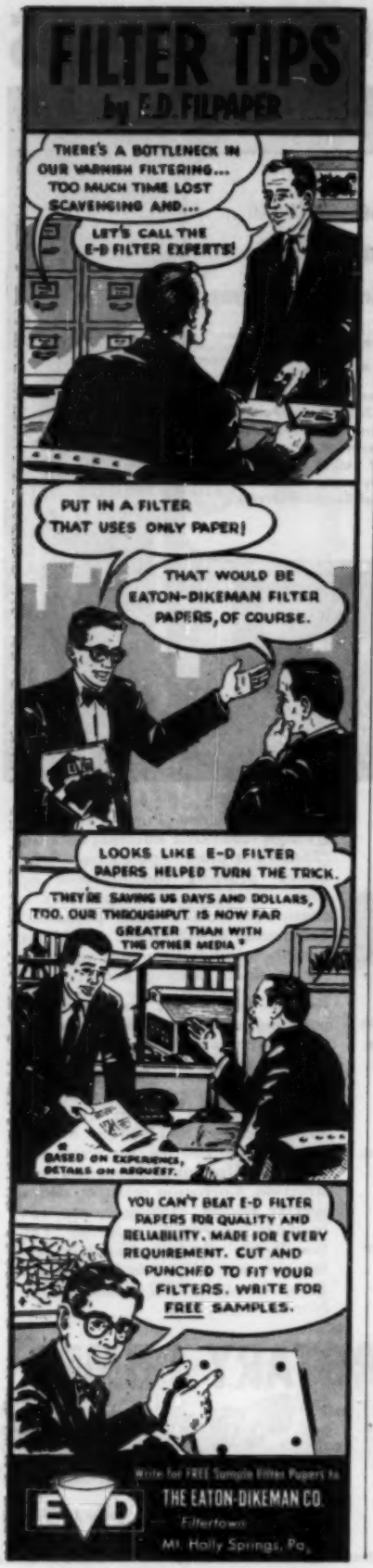
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local sections

from page 117

(J. C. Leitinger). The American engineer was R. J. Payne of Du Pont, and his look at Russia came during a recent ten-day tour of the Soviet Union. Industrial development in the USSR today, Payne said, appears to be concentrated on national defense, housing developments, and food production. Advances in these particular lines are noteworthy. To overcome the Soviet housing shortage, they have standardized on building five and eight story apartment houses.

As a result of the planned industrial development there is almost no progress in some fields. For example, log rafts can be seen floating past modern factories. Television sets are found in rural homes equipped with built-in kitchen ranges which burn wood.

Over 90 High School and Junior High Students attended a career guidance session on chemical engineering opportunities administered by four members of the **Charleston Section** *(G. E. Merryman)* as part of a local area-sponsored program to acquaint students with the variety of career opportunities.

In delineating industry's role in the promoting of higher education, C. C. Furnas of Buffalo U. said to the **Western N. Y. Section** *(C. H. Carr)* that industry must aid higher education as a matter of national survival. "The plain truth is that America, for several decades, and perhaps for several generations, is going to need all the brains it can get."

Clifford C. Furnas, Chancellor of Univ. of Buffalo (r) receiving 7th Annual Professional Achievement Award of Western N. Y. Section, A.I.Ch.E., from Bob Logan, Section Chairman.

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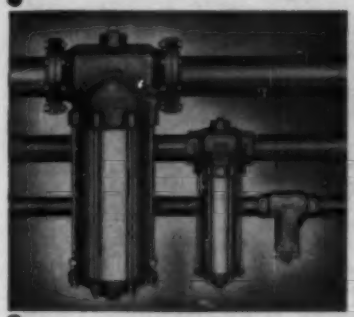

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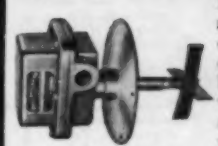

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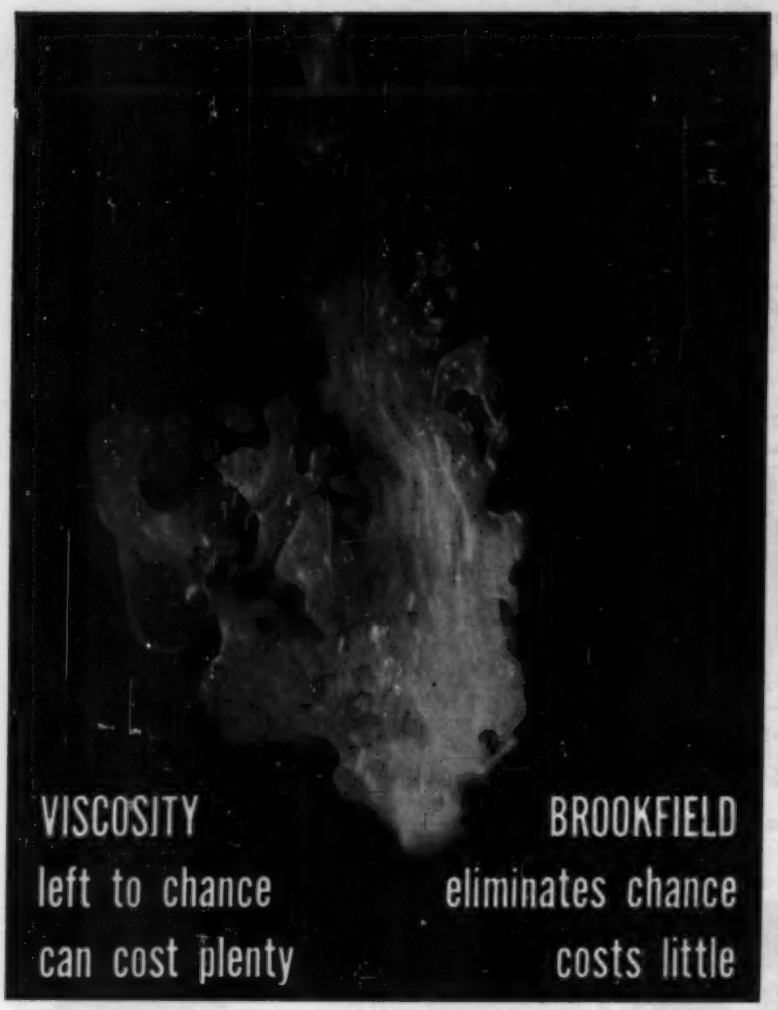

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people in management & technology

Bernard J. Gaffney (left), formerly manager of Rust Engineering's New York office, was named director of engineering for Wood Conversion Co., St. Paul, Minn. In his new post, Gaffney succeeds **Frank A. Morris**, who is retiring after 14 years with the firm.

California Spray-Chemical has appointed **Arthur E. Barta** as associate engineer in its Engineering Department.

Newly-named senior supervising engineers in the Technical Division at Humble Oil & Refining's Baytown, Texas, refinery are **J. W. Alliston** (left) and **T. M. Newsom.** Alliston will supervise the Solvents Section, Newsom the Petrochemicals Section. Also at Baytown, **Ide P. Trotter, Jr.** has joined Humble's Research and Development Division.

G. Boyd McConkey and **John H. Smith** have been named assistant directors in the Engineering Division of Sun Oil Company's Research and Engineering Department. McConkey joined Sun in 1936, and Smith in 1929.

Joseph L. Russell, previously with Dow Chemical's Polychemicals Research Dept., has been appointed director of engineering research for Scientific Design Co.

John E. McKeen, president and chairman of the board of Chas. Pfizer & Co., is serving as 1958 chairman of the Chemicals Industry for the New York State Citizens Committee for the Public Schools, Inc.

The Annual Chemical Engineering Lecture Series at the University of Illinois, December 4 and 5, 1958, was

continued on page 123

A. I. Ch. E. candidates

from page 114

Olander, Donald R., *Berkeley, Calif.*

Papahronis, Basil T., *Crestwood, Mo.*
Pastorius, David Lee, *Woodland Hills, Calif.*
Peter, William A., Jr., *Waynesboro, Va.*

Reed, David H., *Los Angeles, Calif.*
Russell, Paul F., *Emeryville, Calif.*

Schnauts, John A., *The Hague, The Netherlands*
Schrodt, Verle N., *State College, Pa.*
Scott, Robert R., III, *Knoxville, Tenn.*
Sheridan, Peter B., *Dunellen, N. J.*
Smith, Wm. Dean, *Green River, Wyo.*
Sucher, Robert W., *St. Louis, Mo.*

Traylor, Richard W., *Texas City, Tex.*

Walker, L. A., Jr., *Texas City, Tex.*
Wiggen, Eugene R., *Brandenburg, Ky.*
Wohlgemuth, R. E., *Groves, Tex.*

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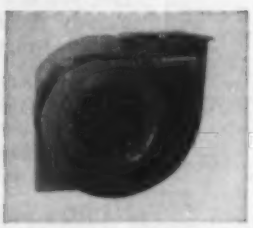

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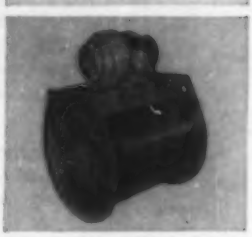

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CHEMICAL ENGINEER—M.S.Ch.E., 1949, family, veteran. Nine years' experience in plastics and chemical industry—including production, process control, research, and development. Desire responsible, challenging position working with people. Box 7-1.

CHEMICAL ENGINEER—B.S.Ch.E., 1953, age 27. Development experience with boron high energy fuels, pyrophoric materials. Pilot plant and miniplant design and operation. Also some production supervision. Desire challenging position in process design, development, or production with progressive company. Box 8-1.

CHEMICAL ENGINEER—B.S., 1954, age 26. Desire responsible position in petroleum refinery. Overseas assignment acceptable. Experience with large engineering contractor in petroleum process design and pilot plant operations. Veteran with overseas duty. Aggressive. Graduate study. Will relocate. Box 9-1.

people in management & technology

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delivered by **Charles R. Wilke**, chairman of the Chemical Engineering Department at the University of California. Wilke is a past winner of the A.I.Ch.E. Junior Award (1951), and delivered the Ninth Institute Lecture at the 1957 A.I.Ch.E. Annual Meeting.

Robert D. Scott has been named vice-president, development of B. F. Goodrich Chemical Co. Scott succeeds **Harry B. Warner**, recently appointed vice-president, marketing.

A new consulting engineering firm has been launched in Tulsa, Oklahoma, by **Charles B. Barry** and **J. A. Richardson**. The firm will offer services as process and evaluation specialists to the petroleum, natural gas, and chemical industries.

D. M. Rogge has joined California Research Corp. as research engineer. He is assigned to the Process and Plant Division, at the company's Richmond, Calif., laboratory.

Leonard J. Edwards has been appointed assistant works manager at the Henderson (Nevada) Works of Stauffer Chemical Co.

John W. Hyde, until recently technical representative in the United States of the Refineries & Technical Department of British Petroleum, has been appointed assistant research co-ordinator, and will be responsible for co-ordination of all manufacturing research throughout the British Petroleum Group.

Executive promotions at American Cyanamid include appointment of

J. F. Bourland as general manager of the Central Research Division, and naming of **W. D. Holland** (left) as asst. general manager of the Plastics and Resins Division.

John J. McKetta, Jr. has been appointed chairman of the Department of Chemical Engineering at the University of Texas. McKetta, who has served on the University staff for 12 years, succeeds the late Kenneth A. Kobe.

Esso Standard Oil announces election of **E. Duer Reeves** as executive vice-president. Reeves has served as executive vice-president of Esso Research and Engineering since 1949. He is the author of the article on Management of the Future in this issue of CEP, page 45.

continued on page 124

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SITUATIONS WANTED

A.I.Ch.E. Members

continued from page 122

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CHEMICAL ENGINEER—Two years high temperature heat transfer and hazard work liquid metals; one year process development, troubleshooting and plant startup petrochemicals. Age 33, family, B.S. in Ch.E. Seek process engineering, pilot plant or production, preferably within 400 miles N.Y.C. Box 11-1.

CHEMICAL ENGINEER—B.Ch.E., age 32, married. Experience: Three years' production; six years' process and development engineering; one year plant and design engineering. Seeking position with medium sized plant giving opportunity to exercise proven engineering ability. Box 12-1.

RESPONSIBILITY WANTED—Proven ability and know-how in petrochemical plant design: process calculations, project engineering, equipment specifications and plant start-up. Experience gained in U. S. and abroad with well known engineering contractors. Age 29, B.Ch.E., P.E., Tau Beta Pi. Publications. Fluent French and German. Present salary $900/month. Box 14-1.

PROCESS ENGINEER—B.Ch.E., M.S. Mgt. Eng. Six and one-half years' experience with leading engineer-contractor and with large chemical company, in process design and development, pilot plant design, start-up and supervision, economic studies. Young, energetic, "self-starter". Salary desired: $10,000. Box 15-1.

CHEMICAL ENGINEER—B.Ch.E., 1957, age 23. Two years' diversified experience R & D. (food, chemicals). Seek challenging position in R & D or design. New York vicinity preferred; will consider relocating. Box 16-1.

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CLASSIFIED SECTION RATES

Advertisements in the Classified Section are payable in advance at 24c a word, with a minimum of four lines accepted. Box number counts as two words. Advertisements average about six words a line. Members of the American Institute of Chemical Engineers in good standing are allowed one six-line Situation Wanted insertion (about 36 words) free of charge a year. Members may enter more than one insertion at half rates. Prospective employers and employees in using the Classified Section agree that all communications will be acknowledged; the service is made available on that condition. Answers to advertisements should be addressed to the box number, Classified Section, Chemical Engineering Progress, 25 West 45th Street, New York 36, N. Y. Telephone COlumbus 5-7330. Advertisements for this section should be in the editorial offices the 10th of the month preceding publication.

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people in management & technology

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William H. McAdams, emeritus professor of chemical engineering at M.I.T., has been awarded the gold medal of the French Institute of Fuels and Energy. The award was established by the French Institute "to recognize the most distinguished achievements in the utilization of fuels and thermal energy." Commenting on the award, Walter G. Whitman, head of the Department of Chemical Engineering at M.I.T., said "With singlehearted devotion Professor McAdams has studied, taught, experimented, and theorized in the field of heat transfer phenomena for over 40 years, exercising leadership in its phenomenal development from crude approximations to its present status of an applied science."

Shown at the presentation ceremony in Boston are (left to right): C. W. Angell, chairman, Boston Section, A.I.Ch.E.; Maurice Car, who made the presentation on behalf of the French Institute of Fuels and Energy; William H. McAdams, emeritus professor of chemical engineering, M.I.T.; and Walter G. Whitman, head, Department of Chemical Engineering, M.I.T.

The 53rd Annual Perkin Medal has been awarded to **Eugene J. Houdry,** inventor of the catalytic cracking process for production of high-octane gasoline. The Medalist is elected by a Jury of Award, representing the American Section of the Society of Chemical Industry, The American Chemical Society, the American Institute of Chemical Engineers, and the American Section of the Societe de Chimie Industrielle.

Raymond H. Marks (left) has been named by Cary Chemicals, East Brunswick, N.J., as vice-president in charge of sales. Marks replaces **Thomas Zawadzki,** former sales manager, who becomes vice-president in charge of product development. Marks was formerly associated with Monsanto Chemical for 9 years.

Peter Virtue has been named a salesman in the New York offices of Godfrey L. Cabot, Inc., Boston, Mass.

NECROLOGY

Louis Veillon, 84, Monsanto Chemical Co. (retired). Veillon, a native of Switzerland, was the first employee of Monsanto Chemical when it was founded in 1901. During World War I, when the United States was cut off from German chemicals, Veillon was one of the leaders in building the American chemical industry.

Elwood K. Pierce, Sr., 63, vice-president and manager of the Houston office, Wm. Powell Vaive Co., Cincinnati.

Ernest D. Wilson, 67, head of the Chemistry and Chemical Engineering Departments, Worcester Polytechnic Institute since 1940.

Edward E. Roberts, 53, assistant purchasing agent, C. O. Bartlett & Snow Co., Cleveland, Ohio.

Frank K. Wengzryn, 24, Callery Chemical Co., Lawrence, Kansas.

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news and notes of A.I.Ch.E.

Member-Gifts Campaign: In December we reported that seven of the Local Sections had already exceeded their quotas for the Member-Gifts Campaign. Now, in addition to these, we report the following: S. Lippa of New Haven has reached 102%, K. H. Pettengill of Ohio Valley 106%, W. Eilinger of Rochester 102%, J. W. Kilmer of Tulsa 100%, and R. C. Johnson of Twin City 116%. At least ten other sections have almost achieved their quotas.

Good News for the Chemicals: We now lead all the other societies as of this writing (December 23), with 75% of the A.I.Ch.E. quota reached, although a number of Local Sections are only now getting underway with their member-gifts campaigns. The closest behind us are the Electrical Engineers with 58% of their quota. If any member of A.I.Ch.E. who has not made his contribution to this century of engineering unity will just write to the office, we will see to it that a pledge card is sent to him or that a campaign chairman from a nearby Local Section calls upon him.

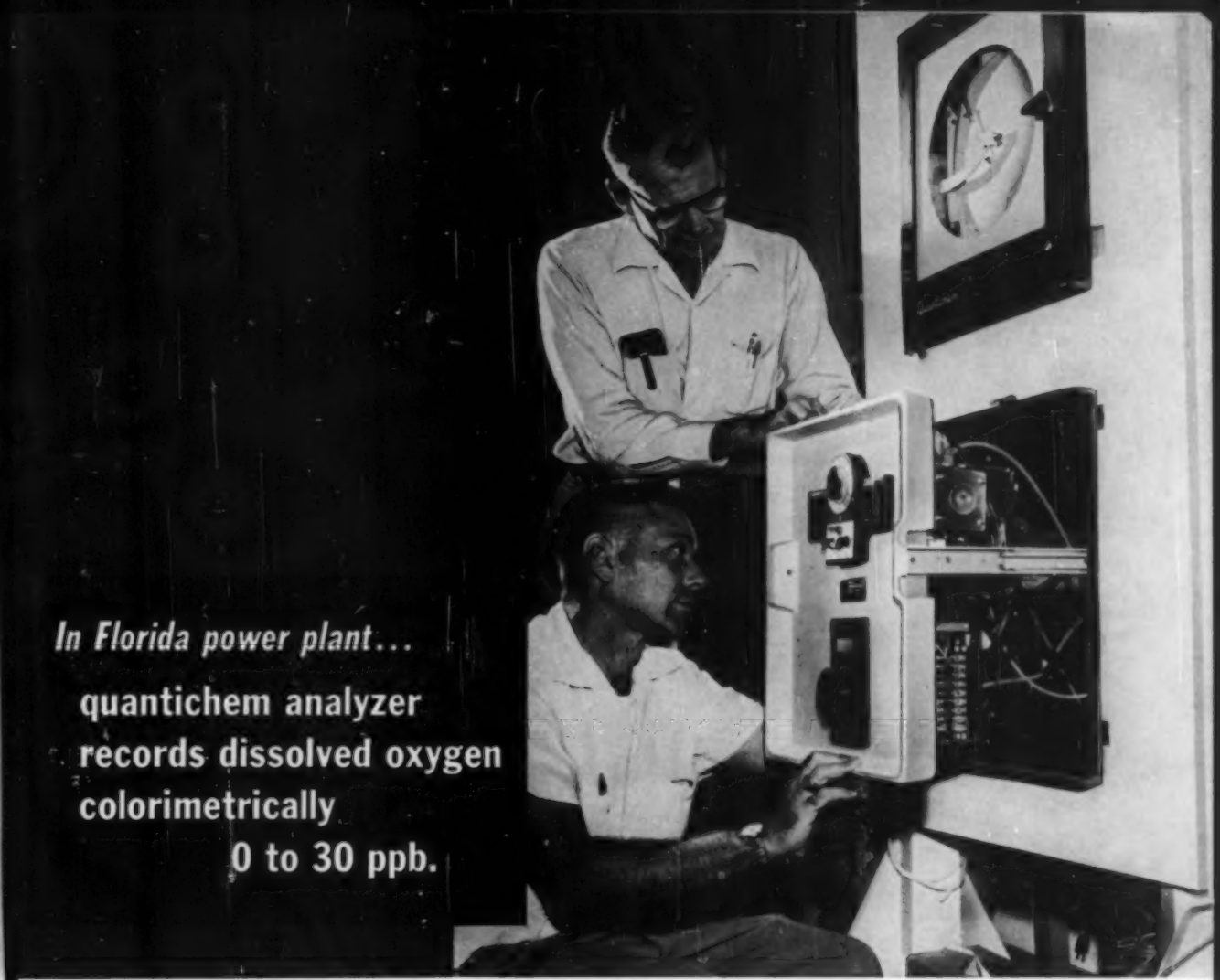
Committee Chairmen for 1959: In addition to those reported last month, the following members were asked by Council to serve as committee chairmen: Membership, E. M. Jones; Nominating, G. E. Holbrook; Professional Development, L. S. Coonley; Professional Legislation, B. B. Kuist; Sections Activities, J. McAfee.

Cincinnati Meeting was affected very little by the airlines strike; attendance reached well over 1,800. Much has been said to me about the outstanding program put on by Alex Brown and the fine arrangements supervised by the Local Section in Cincinnati. Our treasurer, J. H. Rushton, made a rather interesting observation: he calculated that there are approximately 474 people of professorial rank teaching chemical engineering in the United States, of whom about 150 were in attendance at Cincinnati. This is actually quite an outstanding record, revealing a high degree of cooperation between administration and faculty. It also shows the importance that professors attach to their association with A.I.Ch.E. and, as a corollary, to their students' association, both during their college life and after graduation.

Annual Report: The A.I.Ch.E. has printed its first Annual Report, which was distributed at the Business Meeting in Cincinnati and was also mailed

to all Local Section officers, committee chairmen, Student Chapter counselors, etc.—our own V.I.P. list. Will any member of A.I.Ch.E. who wishes a copy of it, of our directory, or of the directory supplement drop a postcard to me personally.

Nuclear Engineering Division: Charlie Dryden, secretary-treasurer of the division, is the author of a statement on the activities of A.I.Ch.E. in the nuclear field which appears in the July issue of the A.S.T.M. bulletin. Also, the division has received a news letter from W. Ken Davis, its chairman, on the Second International Conference on the Peaceful Uses of Atomic Energy held in Geneva in the first half of September . . . Ken relates some of the high lights of the conference and indicates that the general belief was that nuclear power will become economical in several areas within the next ten years or sooner. Charlie Dryden is willing and eager to accept the applications of any who wish to join the Nuclear Engineering Division ($2.00 a year); he can be reached at Ohio State University in Columbus. F.J.V.A.



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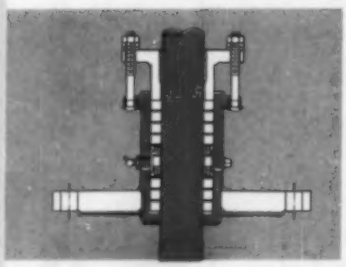

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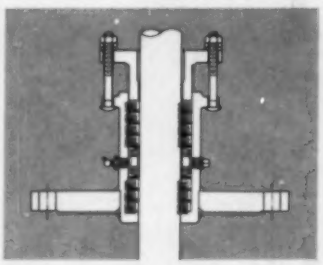
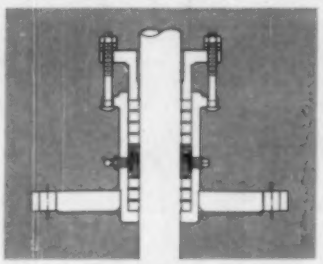
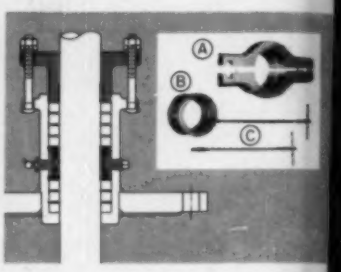


2. GET SUPERIOR SEALING with 7 rings of large-cross-section packing. Separators facilitate packing removal, distribute force uniformly. Gland bolts, threaded part way, prevent overtightening.

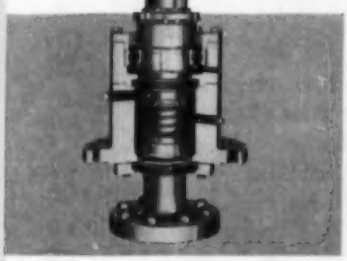


3. GET BETTER LUBRICATION without repacking. Lantern ring evenly distributes lubricant; permits continuous lubrication under pressure; extends time between repackings. Relief plug prevents overlubrication.



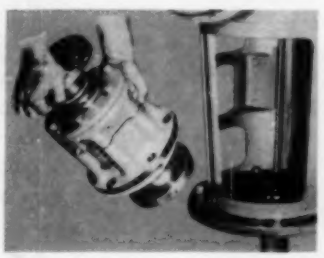
4. REPACK FASTER with exclusive split packing gland (A) that comes right off the shaft to allow maximum work space. Lantern ring (B) lifts out quickly by means of pullers (C), standard accessories.

Get simplest possible maintenance with *Lightnin* mechanical seal*

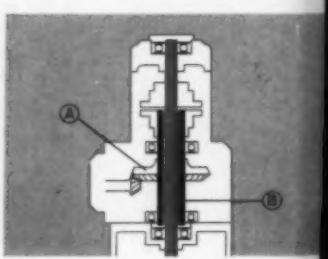


1. ELIMINATE REPACKING and adjustment with this cartridge-type LIGHTNIN rotary mechanical seal assembly, optional on all LIGHTNIN Mixers. It's saving many users thousands of maintenance dollars a year.

2. GET WIDEST CHOICE of seal designs and materials to meet your conditions: stainless steels, Stellite, Hastelloy alloys, bronze, ceramic, Teflon, etc. Handle pressures to 2500 psig and all temperature ranges.



3. REPLACE SEAL ASSEMBLY quickly, if ever necessary—without dismantling mixer or removing it from tank, and *without skilled manpower.* Seal cartridge unbolts, comes out as a unit; replacement bolts in.



4. RETAIN GEAR ALIGNMENT when changing seal. Mixer gears (A) are isolated from shaft by hollow drive quill† (B) *—cannot get out of line* when seal is removed. Shaft realignment is automatic on reassembly.

†patented

WHAT MIXING OPERATIONS are important to you? You'll find a wealth of information on fluid mixing in these helpful bulletins describing LIGHTNIN Mixers:

- ☐ Top or bottom entering; turbine, paddle, and propeller types: 1 to 500 HP (B-102)
- ☐ Top entering; propeller types: ¼ to 3 HP (B-103)
- ☐ Portable: ⅛ to 3 HP (B-108)
- ☐ Side entering: 1 to 25 HP (B-104)
- ☐ Laboratory and small-batch production types (B-112)
- ☐ Condensed catalog showing all types (B-109)
- ☐ Quick-change rotary mechanical seals for pressure and vacuum mixing (B-111)
- ☐ Confidential data sheet for figuring your mixer requirements (B-107)

Check, clip and mail with your name, title, company address to:

MIXING EQUIPMENT Co., Inc., 199-a Mt. Read Blvd., Rochester 3, N.Y.

In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Ave., Toronto 19, Ont.

For more information, turn to Data Service card, circle No. 43

Lightnin® Mixers

MIXCO fluid mixing specialists

*patent pending